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A TEXT-BOOK

OF

CHEMISTRY

FOR STUDENTS AND PRACTITIONERS
OF MEDICINE, PHARMACY
AND DENTISTRY

BY
EDWARD CURTIS HILL, M.S., M.D.
edical Analyst and Microscopist; Professor of Applied Medical Chemistry in the Medical Department of the University of Colorado; Special Lecturer on Chemistry in the Colorado College of Dental Surgery; Chemist of Food and Drug Division, Colorado State Board of Health; Collaborating Chemist, United States Bureau of Chemistry; Consulting Physician, St. Anthony's Hospital, Denver; President of Denver Clinical and Pathological Society (1905-06); Editor of Denver "Medical Times."

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TO THE MULTITUDE OF STUDENTS

WHO, DURING THE PAST EIGHTEEN YEARS,
HAVE FOLLOWED MY INSTRUCTIONS IN
LABORATORY AND LECTURE ROOM

THIS BOOK IS CORDIALLY DEDICATED.

37674

PREFACE TO SECOND EDITION.

THE chemistry of medicine, pharmacy and dentistry is steadily growing in interest and importance. A text-book upon this subject, in the writer's opinion, should be equally serviceable before and after graduation. It should guide the student to a reasoned understanding of underlying principles and be a handy reference book for the practitioner in applying scientific facts and analytic methods in his daily work. In preparing the present revised edition the author has endeavored to make it conform with the latest authoritative knowledge. Nearly every page has been emended and augmented, and many new topics are discussed. Quite a number of new and original tables and colored plates have been included, and the publishers have employed their customary care and skill in making the volume typographically excellent.

Besides the hundreds of references in the text, the author is specially indebted to the following authorities: Lenhartz, Bartley, Attfield, Long, Simon, Sadtler, Bunge, Holland, Muter, Witthaus, Scoville, Hall, Mitchell, Rockwood, Wolf, Gage, Purdy, Draper, Rohé, Taylor, Brundage, Riley, Autenrieth, Tanner, Ogden, Neubauer and Vogel, Heitzmann, Wiley, Leffmann and Beam, Leach, Allen, Mulliken, Winton, Clayton, Richards and Woodman, Ott, Brubaker, Lusk, Bouchard, Halliburton, Coblentz, Sollmann, Croftan, Hatcher, Cushny, Luff and Page, Robinson, Sajous, Hutchison, Findlay, van't Hoff, Pawlow, Cleaves, Essig, Böttger, Fetterolf, White, Jones, McFarland, Einhorn, Prescott, Reid Hunt, Doremus, Vaughan, Mendeleeff, Jelliffe, Novy, Wood, Boston, and the United States Pharmacopœia.

E. C. H.

CORRECTIONS.

Page 32, nineteenth line, read "adsorption" instead of "absorption."
Page 326, "hyoscyin" should read "hyoscin."
Page 263, "serpentaria" should read "serpentarin."

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MEDICAL PHYSICS.

GENERAL DEFINITIONS AND DISTINCTIONS.

EVERYTHING about us consists of matter. Matter is perceived by the senses, especially by sight; but there are also many invisible substances. Air, for instance, though transparent and invisible, is as material in its nature as is iron or salt.

Any appreciable change in matter is termed a phenomenon. Natural, or physic, science is classified knowledge concerning matter and its phenomena.

Chemistry is that branch of natural science which treats of the intimate composition of matter, the changes in composition, and the principles governing such changes. It is, therefore, the most rational of studies, since it seeks to find an ultimate reason for every natural phenomenon. As an art, chemistry has discovered and prepared the greater number of medicinal agents now in use. A practical knowledge of chemistry is as essential to pharmacist and physician as is mechanics to the engineer or draughting to the architect.

Physics differs from chemistry in that it treats of the forces and motions of matter in the mass, rather than its final components. The two sciences are, however, closely related, and an elementary knowledge of physics, or natural philosophy, is essential to the understanding of chemistry. Physic chemistry spans the gap between physics and chemistry, and confines itself to numeric relations between directly measurable magnitudes.

In consonance with the definitions given above, a chemic change is one in which the composition of a substance is permanently altered; a physic change affects only the form, and that temporarily. The conversion of water into steam or ice is an example of a physic change. The union of water with calcium carbid, forming acetylene gas, illustrates what is meant by a chemic change.

Experiment.—Heat 1 gm. of iron filings for ten minutes; then weigh again. Explain change in color and increase in weight. Would these changes have taken place had the metal been heated in a vacuum?

Experiment.—Mix intimately, but cautiously, with a spatula, a teaspoonful of powdered chlorate of potassium with twice as much cane sugar. Place the powder in a convenient vessel and drop on a few minims of strong sulphuric acid. A bluish flame is evoked, the sugar is charred, and a suffocating gas is evolved.

GENERAL PROPERTIES OF MATTER.

The general or essential properties or qualities inherent to all matter are the following: Indestructibility, extension, attraction, weight, divisibility, impenetrability, porosity, compressibility, elasticity, inertia, and mobility.

Indestructibility.—No particle of matter was ever created or destroyed by human or natural agencies. Everything is apparently subject to complete destruction in its final decay, but, in reality, there is only chemic change and new combinations. The vegetation of by-gone ages becomes coal; this is consumed into ashes and gases in the fire which chemic change produces and maintains; living plants live and grow by absorbing the ashes through their roots, and the gases through their stems and leaves; and thus the round of transformation goes on. Water can be resolved by electricity into its component gases, hydrogen and oxygen, the sum of whose weights in any given case is always equal to that of the quantity of the liquid decomposed. The great fact of the indestructibility of matter is the foundation of modern natural science.

Extension.—Extension is that property of matter by virtue of which it occupies space. All forms of matter, even though invisible, possess this property. The amount of space occupied by any given portion of matter is termed its volume, which implies all three dimensions: length, breadth, and thickness. Extension in two directions is called area, or square measure; in one direction, length, or linear measure. By density is understood the ratio between volume and weight. Mass signifies the quantity of matter in a body. The term is not identic with weight, since mass is not affected by gravity, but implies resistance to motion.

The system of measurements employed by scientists in all parts of the world is the metric system. It is a decimal method, the unit of which is the meter, equivalent to 39.37 inches. A cube of water $1/100$ meter on each side ($1/1000000$ cubic meter), weighed at 4° C., is the unit of weight, and is called a gram, being equal to 15.43 Troy grains. The unit of capacity is the liter, represented by a cube $1/10$ meter in each direction ($1/1000$ cubic meter). It is equal to 1000 times the volume of water weighing a gram, or, in the English system, to a little more than a quart.

The subdivisions of each of these three units (meter, gram, and liter) are indicated by the following Latin prefixes: milli, $1/1000$; centi, $1/100$; deci, $1/10$; the higher denominations by the Greek prefixes: deka, 10; hekto, 100; kilo, 1000; myria, 10,000. It is thus seen that a gram is the weight of a cubic centimeter of water, and that 1000 cubic centimeters, or a liter, weigh a kilogram. Metric abbreviations are derived from the first letters of each name: *e.g.*, c.c., for cubic centimeter; mg., milligram, etc.

The metric terms used in medicine and pharmacy are the liter, cubic centimeter, gram, milligram, and micron, the latter being a microscopic denomination equal to $\frac{1}{1000}$ millimeter, or $\frac{1}{1000000}$ meter; it is expressed by the sign or letter μ. A micromicron ($\mu\mu$) is one millionth of a mm. The student should learn the doses of drugs according to the metric system, bearing in mind that a teaspoonful or fluidram of liquid medicines is practically the same as 4 c.c. The following prescription illustrates the advantages of the metric system in prescription writing. The numbers represent either grams or cubic centimeters, according as the substance is liquid or solid. The perpendicular line stands for the decimal point, separating whole numbers from fractions:—

℞ Quininæ sulphatis	2	400
Caffeinæ citratis	1	200
Acetanilidi	1	800

Fiat pulvis; divide in capsulas numero xij.
Signa: One every three hours.

Impenetrability.—No two bodies can occupy the same space at the same time. There are many apparent exceptions to this axiom. Sugar disappears without increase in volume of the water. The air seems to offer no hindrance to the presence of other material objects.

Experiment.—Place a piece of lighted candle on a wide cork floating on water in a wide vessel. Over the cork and candle press down a tall bell jar. They will be seen below the outside surface of the liquid.

Divisibility.—The limits to which matter may be divided are almost beyond comprehension. Take any solid substance and crumble it in a mortar or dissolve it in a liquid; yet we know that the farthest possible division has not been reached. Under a high power of the microscope the fine grains of the powder appear large and rough and obviously capable of further division. Regarding matter in solution, a grain of strychnin renders distinctly bitter a whole barrel of water. According to Berthelot, it would take about 1000 centuries for a gram of musk, constantly scenting the surrounding air with particles or gas, to lose 1 mg. in weight. One grain of uranin or fluorescein will color or render fluorescent 100,000,000 grains of water.

Yet it is believed, on good mathematic grounds, that divisibility has its bounds, and this leads us to the molecular theory of the constitution of matter. Scientists hold that every substance is composed of infinitely minute separate particles, or molecules, separated by interspaces that are comparatively much larger (according to Maxwell, about ½ millionth inch in ordinary air). The molecules are in constant motion (8,000,000,000 collisions per second in air—average speed, 1570 feet per second, at 15.5° C.), striking against each other and so producing the varied forms of molecular energy known as heat, light, magnetism, and electricity. The existence of intermolecular spaces is shown by the passage of coal gases through red-hot iron, by the forcing of water under hydraulic pressure through metals, and by the fact that there is no increase in the volume of a liquid when a salt is dissolved therein.

According to the relative proximity of the molecules to each other, generally speaking, we have three principal states of matter: solid, liquid, and gaseous,—to which, perhaps, a fourth, or extragaseous—including the luminiferous ether and the so-called radiant matter of artificial vacua—may be added. These states are interchangeable under varying conditions of temperature and external pressure. By the aid of heat, ice is converted into water, and this into vapor. Air itself has been frozen under great pressure, into a gray powder. The conversion of a gas into a liquid or a solid is brought about either by reduction of heat or by pressure or both.

Regarding the actual size of a molecule, the human mind fails to grasp its nearly infinite minuteness. Lord Kelvin estimates that they range from $1/100000000$ to $1/10000000$ cm. in diameter. Gas molecules are reckoned to range from 0.0001 to 0.00066 micron. There are millions of molecules in the head of a pin. A crude comparison is that the volume of a drop of water is to that of each molecule of which it is composed as the size of the earth is to that of an apple.

Minute as are molecules, they are known to consist of even smaller solid bits of matter called atoms, which exist, as a rule, only in combination, forming molecules. When the constituent atoms are alike, the molecules, and—of course—the substance which they compose, are termed simple; a compound molecule or substance is composed of unlike atoms.

Crookes and Thomson have seemed to prove that even atoms are made up of infinitesimal, negatively charged particles (electrons), which move in orbits, and are thrown off from all highly heated or highly electrified bodies. The hydrogen atom is computed to consist of 700 units of electricity; the oxygen, of 11,200; the radium, of 157,500. These electrons, it is said, bombard space and its contents at the speed of 50,000 to 100,000 miles per second, giving rise to all sorts of perturbation in the ether, such as, for example, fluorescence and X-ray phenomena. According to this theory, the ultimate particles of matter and force are identic, and the mother-substance is known as protyle, or pantogen (urstoff, fire mist, fourth state of matter). Bowker holds that concrete matter is made up of active or energized ions, chips, or corpuscles; whereas the universal ether consists of passive or inert "ons."

Attraction.—The grand law of gravitation, discovered by Newton, is to the effect that every portion of matter in the universe attracts every other portion with a force which varies directly as the mass or quantity of matter in the bodies, and inversely as the square of the distance. The term gravity is applied to the attractive force which the earth has for bodies on or near its surface.

In addition to this molar form of attraction active at sensible distances, the molecules of each substance are held together by molecular attraction, and the atoms by chemism, or chemic affinity, which is similar to, if not identic with, magnetism. Molecular attraction is of two general kinds: cohesion, or that between like molecules; and adhesion, or that between unlike molecules. The continuity of a drop of water is an example of cohesion; water wetting the finger is an illustration of adhesion. Both cohesion and adhesion are forms of surface-action. When the action of gravity is suspended, cohesion causes a liquid to assume the globular shape. Heat, the repellent force, is the great antagonist of cohesion, whereas it may aid adhesion, as in the case of most solutions. In solids, cohesion prevails over the repellent force; in liquids the two forces are about equal, and the molecules move around each other freely; in gases the repellent force predominates; so that the tendency of a gas is always toward greater expansion.

Weight is the measure of gravity. When we say an object weighs a pound we mean that the earth, as a whole, draws it to an extent balanced by this certain weight. The greater the mass of the object and the nearer it is to the surface of the earth, the greater the attraction and also the weight. At the center of the globe a body would weigh nothing at all, since the attraction of the encompassing world-matter is equal in all directions. A fluidounce of water weighs 456 grains. To find the weight of a given volume of water divide by 0.96 (avoirdupois) or by 1.05 (Troy ounces).

Specific gravity is the relative weight of a substance as compared, under similar circumstances of temperature and pressure, with an equal volume of another substance taken as a standard. Water is the standard for both solids and liquids; air or hydrogen for gases. In the latter instance we speak of the comparative weight as density, rather than specific gravity.

Porosity.—The existence of inconceivably minute, though relatively large, spaces between the molecules has already been noticed. It is into these pores that in case of a solution the particles of the dissolved substance enter. The extent of these interspaces is increased by molecular motion (heat); hence, hot liquids, as a rule, can dissolve more of a given substance than cold ones. The hardest and densest metals can be made, under hydraulic pressure, to show the presence of pores.

Experiment.—Mix 50 c.c. each of water and alcohol. Take the reading again in ten minutes, and note how much it falls short of 100 c.c.

Compressibility.—This property obviously depends on the preceding one, and, as we might expect from the relative distances between the component molecules, gases are more compressible than solids, and these usually more so than liquids. That most liquids are less capable of compression than most solids is due largely to the absence in fluids of sensible pores or interspaces. The compressibility of solids is illustrated by the stamping of coins with dies.

Elasticity.—By this term is meant the tendency of a body to return to its original shape after being compressed, stretched, bent, or twisted, from which we have the four kinds, namely: elasticity of compression, of tension or traction, of flexure, and of torsion. The first form is a general property of matter, though varying greatly in different substances. Gases are the most elastic form of matter; liquids come next in order; solids are very variable.

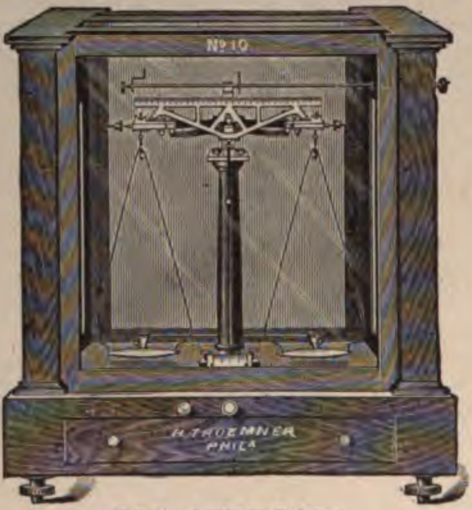


Fig. 1.—Analytic Balance.

Inertia.—There is always a cause for every effect, and the property of inertia signifies that nothing material can of itself change its position or condition. Without the influence of external agents everything in the world would remain the same, inert and unvaried for all time. The active agents of natural, as opposed to artificial, changes are, first of all, the bacteria, those teeming micro-organisms which keep going the circle of life on the planet by breaking down dead animal and vegetable matter into more simple and available forms for living things. Most of these germs are innocuous, but some give rise to deadly chemic products, which are, in turn, responsible for infectious diseases.

Mobility.—All matter is in a state of constant motion; rest is only a relative term. We may distinguish between mechanic (visible or sensible) change of place and invisible motion, molecular and atomic—the former giving rise to the physical forces of heat, light, magnetism, and electricity; the latter to the manifold manifestations of chemic energy.

Velocity is the rate of motion in any given time. Momentum, or quantity of motion, is the product of velocity and the mass. Force is that which causes, alters, or arrests motion. Energy is the capacity for doing work; it depends on the union of motion and mass. Potential energy refers to position or condition, as of the water in a mill dam above the wheel; or of water vapor, which, in condensing, gives out the amount of heat required for evaporation. The potential energy of a pound of coal (11,000,000 foot-pounds) is equivalent to a hard day's work by a strong man. Actual, or kinetic energy, is that of matter in motion. Plants generate potential energy, which animals render kinetic. The measure of kinetic energy is one-half the product of the mass times the square of the final velocity. There is a general tendency toward the conversion of all forms of energy into heat.

Work is energy applied to overcome resistance. In Nature, whenever any change can accomplish work, it will proceed when resistance is absent. The unit of work, according to the English system, is the foot-pound: that is, the amount of force required to raise one pound one foot in height; the corresponding metric unit is the kilogrammeter. A horse-power is equivalent to 33,000 foot-pounds per minute. Machines gain in force, but lose in space.

In the C. G. S. (centimeter-gram-second) system, the dyne is the unit of force. It is equivalent to the weight of 1.02 mg. A megadyne is a million dynes. The erg (one dyne acting through 1 cm.) is the unit of work; a megaerg, 1,000,000 ergs. A horse-power equals 7458 megaergs. The joule (Wj) represents 10^7 ergs. The poundal is a unit of force acting on one pound for one second, generating a velocity of one foot per second. A watt equals one joule per second.

The grandest law in Nature is that of the conservation and correlation of forces: nothing is wasted, nothing lost. The rays of the sun have produced coal, the coal serves as fuel to the steam engine, the engine runs the electric dynamo, and the latter gives back the heat and light first furnished by the sun.

SPECIAL PROPERTIES OF MATTER.

The special properties of particular substances are modifications of the general attributes of matter. The three states of matter—solid, liquid, and gaseous—are dependent upon the balance between cohesion and heat: in other words, on the distance between the molecules. Every gas and liquid can be converted into the liquid or solid state by two methods, namely: by cold and by application of pressure, singly or combined. Nearly all solids likewise can be melted into liquids and then vaporized. A few solids—sulphur, for example—pass directly into the gaseous form on heating sufficiently.

SOLIDS.

The peculiar properties of solids worthy of mention are hardness, brittleness, tenacity, malleability, ductility, elasticity, flexibility, viscosity, and crystallizability. All of these are simply modifications of the essential property of cohesion.

By the term hardness is meant resistance to scratching or mechanic erosion. We say that iron is hard, lead soft. The degree of hardness bears no relation to density; lead is half again as heavy, or dense, as iron. We judge of the relative hardness of any substance by comparing it with others taken as standards. Mineralogists use a convenient table of ten minerals, each of which represents a certain degree of hardness corresponding with a certain number. The scale is as follows:—

1. Talc.
2. Gypsum.
3. Calcite.
4. Fluorspar.
5. Apatite.
6. Orthoclase.
7. Quartz.
8. Topaz.
9. Corundum.
10. Diamond.

The diamond is the hardest known substance. It is used in miners' drills and for cutting glass; the cheaper glasscutters are made of steel. Hard bodies are much used as polishing powders, among which may be mentioned emery, pumice, tripoli, and diamond dust. Blacksmiths and workers in iron and steel harden tools and implements by dipping them, while heated, into cold water. This process, called tempering, usually renders the metal more brittle. The best quality of glass is allowed to cool slowly, thereby becoming tougher and stronger; the process is known as annealing.

Brittleness is a lack of cohesive power, shown by the body breaking when subjected to a moderate strain or to a fall or blow. All brittle substances are hard; but the converse is not true. The well-known brittle quality of glass has become a proverb the world over.

Experiment.—With a three-cornered file make a slight cut in a glass tube. Place a thumb on either side of the cut, on the opposite surface of the glass. With the remaining fingers make pressure toward the thumbs. A neat fracture takes place readily.

When a body is once broken, it is usually impossible to press the fragments close enough together for cohesion to act.

Glass and china can be mended only by the use of a different adhesive material, termed cement, which forms, as it were, a connecting link between the broken pieces. In the case of wrought iron, however, a break can be remedied by the operation of welding, by which the molecules of the separate fragments are made to flow around each other in the molten state, aided by the use of the hammer. Freshly cut lead can be made to cohere again on strong pressure.

Experiment.—Take two glass slides and place between them a few drops of water, pressing out the latter, and with it the atmospheric air. Considerable force will be required to pull the pieces apart. What two things are concerned in the resistance to the pulling efforts?

Tenacity is that property of matter by virtue of which it sustains weight and resists a pulling force. The property varies greatly in different substances, and even in the same body. A piece of wood, for instance, is more tenacious in the direction of the grain than across it. Tensile strength is lessened by continuous strain. An iron wire $\frac{1}{10}$ inch in diameter will sustain a weight of 700 pounds. A band of fresh human muscle, 1 sq. cm. in cross-section, was able to resist, without rupture, a weight of 14 kg. (McAlister). Closely related to tenacity are the properties of elasticity, ductility, and malleability.

Elasticity of compression is a general property of matter. Elasticity of flexure or bending, extension or stretching, and torsion or twisting are restricted to solids. It is evident that in an elastic body the molecules return nearly or quite to the relative positions they occupied before being acted upon by the outside force or stress.

Malleable bodies are such as can be hammered or rolled into sheets. Gold and copper are the most noteworthy of the metals in this respect. A piece of the former metal can be beaten into a film $\frac{1}{300000}$ of an inch in thickness, and to 650,000 times the original area.

A ductile substance is one that can be drawn out into threads or wires. Platinum can be spun into a web finer ($\frac{1}{300000}$ inch) than that of the spider. Gold, iron, and copper are also remarkably ductile. Certain substances—as sugar, waxes, quartz, soapstone, and glass—are ductile when heated sufficiently, and dresses even have been woven out of glass. Owing to increase of density, the strength or tenacity of a body is increased when it has been drawn into wire or rolled or hammered. It is rendered more elastic and at the same time more brittle.

A flexible body is one which will bend without breaking. It is usually also more or less elastic. In the case of a flexed body the molecules on the inner side must be crowded closer together, while on the outer aspect they are drawn farther apart. Metallic rods and wires, particularly copper, are, as a rule, quite flexible. Certain brittle materials are readily bent on heating.

Experiment.—Hold a piece of soft glass tubing in the flame. In a few seconds the glass can be bent, heated portion inward, to any required angle.

Viscosity is a property exhibited by some brittle substances, on account of which they yield and bend under continued stress. If we fasten a piece of sealing wax horizontally by one end, and to the other attach a weight, in course of time the wax will be seen to be bent downward. Ice is viscous, as shown by glaciers conforming to the shape of the valleys through which they slowly move.

Crystalline bodies are such as have a more or less regular shape. Most natural inorganic substances are crystalline; for example, common salt, alum, and sulphate of copper. Those substances which are not crystalline are termed amorphous: that is, without form.

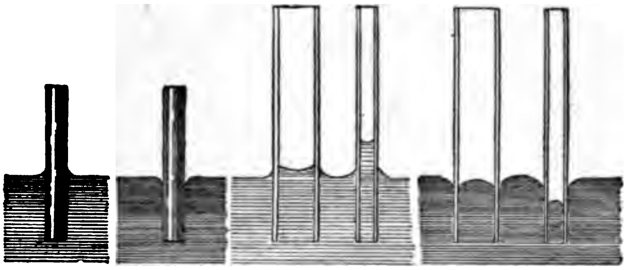


Fig. 2.—Capillary Attraction and Repulsion.

LIQUIDS.

A useful and remarkable property manifested by liquids is that of capillary attraction and repulsion.

Experiment.—Hold a fine glass tube in a beaker of water, and another in a beaker containing mercury. The water rises in the capillary tube, because the adhesion between the two is greater than the cohesive force of the water. The mercury is apparently repelled by the glass, since the cohesion of the metallic liquid is greater than its attraction for the glass.

The most marked examples of these phenomena are seen in the smallest tubes, as a greater relative surface is thus provided for the exercise of attraction or apparent repulsion. Capillary action is of immense importance in Nature and in everyday life. In this way the sap rises in plants and the oil in the lamp, the blotting paper takes up ink, the towel dries our hands, and the filter paper separates liquids from undissolved solids.

By the diffusion of liquids is meant their natural unaided physic admixture when their surfaces are brought into contact. This process will take place, though more slowly, when the lighter fluid is placed on top the heavier, as alcohol on water. Some liquids will not mix with each other directly at all.

Experiment.—Shake a little water in a test tube with an equal quantity of oil of turpentine, and notice how quickly they separate. Which goes to the top?

Water and alcohol, but not water and ether, mix in all proportions homogeneously, with contraction and increase of temperature. By heating, all liquids may become miscible.

The slower diffusion, or passage, of two liquids into each other through parchment paper or an animal membrane is called osmosis. Generally speaking, the lighter of two liquids traverses a porous septum more rapidly than the heavier one; its flow is termed endosmose; that of the heavier liquid, exosmose. Crystalline substances have usually smaller molecules than amorphous ones; hence they pass more quickly through a porous partition. Cane sugar diffuses seven times as fast as albumin. Bodies capable of ready osmosis are therefore termed crystalloids (diffusates); those otherwise constituted are called colloids (dialysates), which means, literally, glue-like. Colloids in the soluble state are termed sols (hydrosols in water); in the solid state, gels.

The operation of separating colloids from crystalloids has been termed dialysis. By this process any crystalline poison, such as arsenic or strychnin, can be easily separated from the colloid food contents of the stomach, in a case of suspected poisoning. Dialysis is also of use in the preparation of dialyzed iron and some other drugs. (See also under "Osmosis.")

Surface Tension.—All liquids, says Draper, act as though their superficial layer was subjected to tension which exerts a contractile force or pressure upon their interior mass, owing perhaps to the unbalanced inward attraction on the outermost layer of molecules. This surface tension acts as an elastic limiting membrane, tending to draw the particles of liquid to the smallest possible compass and form; namely, a sphere, as exemplified by soap bubbles. The apparent repulsion, with floating, of dry or greasy bodies (sulphur, arsenous oxid, a sewing needle) heavier than water, illustrates this tension from the external point of view. Sublimed sulphur, placed carefully on the surface of cold urine containing bile-pigment, settles quickly, but slowly, or not at all, in normal urine. The difference is due to some alteration of surface tension. Alcohol, chloroform, phenol, etc., in the urine, simulate bile-pigment in this test.

Pressure of Liquids.—The perfect fluidity of water and most other liquids accounts for the well attested fact that at any given point in a liquid the pressure is the same in all directions: up, down, or horizontally. This pressure is due to gravity,—that is, to the weight of the superincumbent liquid,—and, hence, of course, increases with the depth. The pressure at the bottom of the sea is 500 to 600 kg. per sq. cm.

Experiment.—To show that water presses upward as well as downward: Attach a string to the center of a metal disk large enough to cover the bottom of a glass cylinder; a small lamp chimney will answer. Draw the string through the tube, holding it taut, and press the cylinder down into a vessel of water. At the depth of a few inches, one may let go the string, and the upward pressure of the liquid will keep the disk from sinking.

Experiment.—To prove that at the same point the pressure is equal horizontally and perpendicularly: Take two long glass tubes, and bend one end of each to form a U, the open end of this facing upward in one, outward in the other, both openings being at the same level. Pour a fluidram of mercury into each tube and immerse the U-ends in a deep glass vessel of water. The quicksilver will rise in both tubes to the same height.

The free molecular movements and equal transmission of pressure in liquids cause their surface to be always level when at rest, since in this condition only is equilibrium possible; or, as expressed in the old saying: "Water seeks the lowest level." Masons, carpenters, and surveyors make use of a spirit level for determining horizontal lines and planes. This instrument consists of a slightly curved tubular glass receptacle set for convenience in a block of hard wood, and nearly filled with alcohol. A small space is thus left for an air-bubble, which rises to the center of the glass when the instrument is horizontal.

On account of the equal distribution of pressure in all directions, a small quantity of liquid may apparently counterbalance a much larger amount, as in the familiar example of the tea in the nozzle and the body of the teapot. The same principle is illustrated in the hydraulic press, used for exerting great pressure or for lifting great weights. This apparatus consists essentially of a large cylinder perforated by a narrow conduit, each fitted with a piston. When the water is passed through the small tube into the larger space it exerts on the sides of the latter a distending force as many times greater as the difference between the cross section of the pipe and the inner area of the cylinder. Yet, in reality, the total amount of energy has not been increased, since the smaller piston descends a correspondingly greater distance than the larger one rises.

The same principle of hydrostatic equilibrium is exemplified by artesian wells. The fountain character of these wells is due to the pressure of water at a higher level upon that inclosed in a hollow between impervious layers of clay, and which is tapped by boring. "Water cannot rise higher than its source," and, owing to friction of soil and air, the heights of these wonderful fountains are probably much below the level of their origin.

Pressure on Immersed Bodies.—The difference between the pressures on the upper and lower surfaces of a body immersed in a liquid is evidently equal to the weight of the liquid displaced, since such pressure increases in exact proportion with the depth. This difference represents likewise the apparent loss of weight of a solid substance when immersed in a liquid, or the so-called buoyant force of liquids.

Experiment.—Weigh a piece of iron in air and then suspend in water. How much does it appear to lose in weight? Now weigh the water and vessel before and after immersion of iron. How much do they appear to gain in weight?

Since the apparent loss of weight of the solid equals the weight of liquid displaced, it is easy to find by simple comparison their relative weights, which in the case of water is called specific gravity. To find the specific gravity of the iron in the above experiment, we need, therefore, only to divide its weight in air by its apparent loss of weight when weighed in water.

If we use metric measures the solid need be weighed only in air. It is then placed in a carefully measured quantity of water in a metric graduate. The number of c.c. the water rises is equivalent to the mass of the solid, and a comparison of this rise with the weight in grams of the solid shows at once the specific gravity. This applies to fine powders as well as concrete masses.

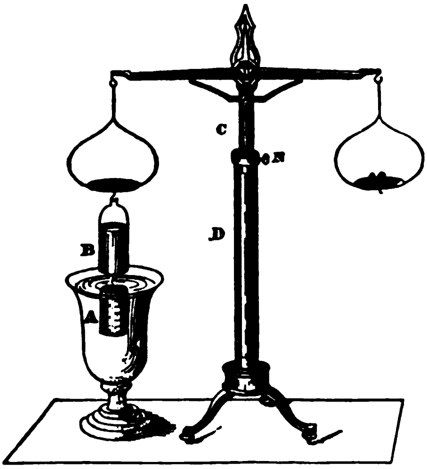


Fig. 3.—Hydrostatic Balance.

Experiment.—Find the sp. gr. of a silver dollar.

The volume of an irregular body is readily estimated by weighing it in air and then immersing it by a string in water and weighing again. The apparent loss of weight in grams equals the volume of the body in cubic centimeters. By specific volume is meant the reciprocal of the sp. gr., *i.e.,* the volume of unit mass.

If a solid is soluble in water, we may ascertain its relative weight in some other liquid not a solvent, multiplying the result by the known sp. gr. of the liquid employed.

Experiment.—Find sp. gr. of cane sugar, using turpentine as a medium.

With solids lighter than water a lead sinker is attached. The calculation is made as for heavy substances, bearing in mind, however, that the light object weighed in water appears to lose its own weight and more. For example, a piece of lead weighing 10 gm. in water has attached to it a piece of cork weighing 2 gm. in air. The two now weighed in water weigh 4 gm. The apparent loss of weight is 12 — 4 = 8 gm. Dividing 2 gm., the weight of the cork, by 8 gm., its apparent loss of weight in water, we find its sp. gr. to be 0.25.

The picnometer, or specific gravity flask, is a thin, round bottle with a perforated glass cork and a counterpoise. The flask is usually made to contain from 10 to 100 gm. or c.c. of water at 15°C. If when filled with chloroform the weight of contents is 15 gm. in a 10 gm. bottle, we know that the sp. gr. of the liquid is 1.5.

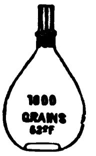


Fig. 4.—Picnometer.

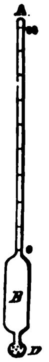


Fig. 5.—Hydrometer.

Experiment.—Find the sp. gr. of alcohol with the picnometer.

The sp. gr. of liquids, however, is usually taken with the hydrometer, which is an instrument consisting of a graduated stem above, a hollow cylinder midway, and a bulb below containing quicksilver or shot. The instrument depends on the theorem of Archimedes, that a body immersed in a liquid displaces its own volume and loses weight equal to the weight of the liquid displaced, and that the immersed body sinks until it has displaced a volume of the liquid equal to its own weight.

The stem of the instrument is marked so that the surface reading is 1.000 for pure water (at 15° C., unless otherwise stated —U. S. P., 25°C.), and so on up or down with solutions of known sp. gr. The Baumé scale instruments are of two kinds: for liquids lighter than, and for those heavier than, water. The Baumé hydrometer is graduated by taking a 10-per cent. solution of sodium chlorid as 10° on the scale. The reading is generally taken at the top of the meniscus, or little ring of liquid clinging upward around the stem of the instrument. Modifications of the hydrometer for special fluids are the urinometer, the lactometer (for milk), salimeters, saccharimeters, vinometers, and alcoholimeters.

The influence of surface tension, which is different for different liquids, at the place where the stem of a hydrometer comes in contact with the surface of a liquid, may produce, says Traube, an error of from two to four units in the third decimal place; so that the same hydrometer is applicable only for a single liquid.

The sp. gr. of liquids can also be determined by weighing a solid body of known weight in them. It is evident that the apparent loss of weight of the solid is greater in the heavier liquid than in the lighter one, and their relative densities are obtained by a simple ratio. For example, a piece of iron loses, let us say, 2 gm. by weight in water, 1.45 gm. in ether; the sp. gr. of ether is the ratio of 1.45 to 2, or 0.725. This principle is utilized in the convenient Westphal balance, consisting of a notched beam attached at one end to a perpendicular support, and having at the other end a hook supporting a rider, a thermometer, and a glass plummet. When these are immersed in distilled water at 15°C. the arm of the instrument is exactly horizontal. In liquids other than water the sp. gr. is read at a glance from the numbered notches on which riders of various sizes are placed in order to bring the arm to the horizontal. The sp. gr. of water at 100°C. is 0.95859.

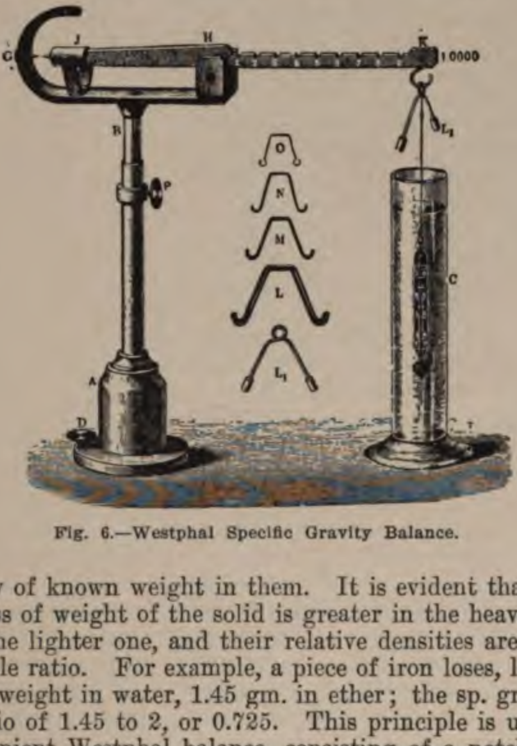


Fig. 6.—Westphal Specific Gravity Balance.

The sp. gr. of crystals is determined with great precision by floating the crystal on the surface of methylene iodid in a separatory funnel, then adding benzene until the crystal floats just in the middle of the liquid, the sp. gr. of which, as determined by the hydrometer, is now the same as that of the crystal.

GASES.

The constitution of gases is in many respects more simple than the structure of solids or liquids. The Italian physicist Avogadro and the French electrician Ampère discovered and demonstrated about the same time the following law: Equal volumes of all bodies in the gaseous state and at the same temperature contain the same number of molecules. The necessary corollaries of this principle are, first, all gaseous molecules occupy the same space; second, the relative weights of any two gases are to each other as the weights of their molecules.

The volume of a confined gas is inversely proportional to the pressure brought to bear upon it. This statement is called Mariotte's law. One atmosphere (760 mm. of mercury) is taken as the standard of pressure. Specific volume is the volume in c.c. of a gas which 1 gm. occupies at 0° and 760 mm. barometric pressure.

Charles's law is to the effect that the volume of any substance in the gaseous state varies directly as the absolute temperature. It has been found that a lowering of temperature from 1° to 0°C. reduces the volume of a gas by $\frac{1}{273}$, or *vice versâ*. Hence at a point 273° below zero (the temperature of interstellar space), all molecular motion must cease and the molecules be in contact with each other. This is called the absolute zero, from which absolute temperature is reckoned. In calculating the volume of a gas zero centigrade is considered the standard.

The kinetic theory of gases assumes that the mean velocities of the molecules of gases are inversely proportional to the square roots of their densities. The tendency to expansion exhibited by all gases is due to the repulsion between the molecules. All gases expand at a uniform rate (co-efficient of expansion) for equal increments of heat: $\frac{11}{3000}$ increase in volume for every degree above 0° C. The constant tendency of an inclosed gas to escape from its container is called its tension, pressure, or elastic force, and this can be measured by a mercurial manometer. The tension and the density of an inclosed gas vary inversely as its volume. Boyle's law states that the product of the pressure times the corresponding volume of gas is always constant when the temperature is the same. Saturated vapors do not follow the Boyle-Mariotte law. The rupturing force of explosive compounds depends on the liberation of a large amount of gases in a very short time. Dynamite is said to explode in $\frac{1}{24000}$ second.

The diffusion, or mixing, of one gas with another depends upon tension, and the rapidity of diffusion varies inversely as the square root of the density of each gas. Wet membranes allow the diffusion of soluble gases more readily than do dry ones, as exemplified by the diffusion of carbon dioxid from the blood into the lungs. Damp walls are unhealthful, because they prevent normal diffusion of air.

We live at the bottom of an aerial ocean at least ten times as deep as the watery oceans which envelop the land. The air, like all gases, is a perfect fluid, and hence subject to all the laws of pressure and equilibrium of liquids. The pressure of the atmosphere at sea-level is about 15 pounds to the square inch, or the equivalent of the weight of a column of mercury 760 mm., or 30 inches, in height. As we ascend from the level of the ocean the atmospheric pressure gradually lessens, so that at Denver, for instance, it will sustain a column of mercury but 25 inches high, and at an altitude of 3⅓ miles only 15 inches. The barometer is an instrument for measuring atmospheric pressure. It was invented by Torricelli in 1643, and consisted of a simple glass tube closed at one end. The tube is filled with mercury and then inverted in a basin of the same, when the metal sinks until its own weight equals the pressure of the atmosphere on an area the same as that of a cross-section of the tube. This primitive arrangement, properly graduated, is still in use under the name of the cistern barometer. The ordinary mercurial barometer consists of a long arm joined to a short one, the former being closed above, the latter open. The space above the quicksilver in the long tube is termed a Torricellian vacuum. The difference in level of the height of the liquid in each arm represents the atmospheric pressure. This varies with altitude and with the temperature and humidity of the air. At sea-level in fair weather it is 760 mm., or a little more than 30 inches.

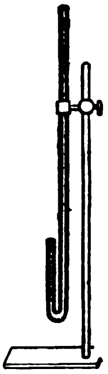


Fig. 7.—Mercurial Barometer.

Fair weather is manifested by a high barometer; a sudden fall foretells a storm.

It is readily seen that the barometer can be used for ascertaining the heights of mountains or the distance above sea-level at any elevation. For this purpose the convenient aneroid barometer is usually employed. It consists of an hermetically-sealed, flat, circular box of corrugated sheet-iron exhausted of air. The sides of it are pressed in more or less with each variation of atmospheric pressure, indicated by a needle on the dial face connected with the interior arrangement of levers.

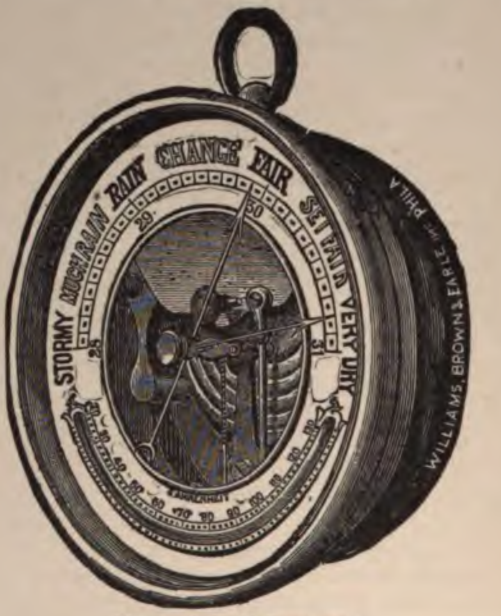


Fig. 8.—Aneroid Barometer.

To find the altitude in feet, approximately, from the barometer, subtract the reading, in hundredths of an inch, of the higher altitude from that of sea-level or at the base of the mountain, and multiply the difference by 10.

On atmospheric pressure depends the action of pumps, siphons, bulb-syringes, pipets, and medicine-droppers. The pressure of the air (at sea-level) will sustain a column of water 34 feet in height, and this is evidently the greatest distance that water can be raised by means of a suction pump. The propelling force of a liquid in a siphon is equal to the difference between atmospheric pressure and the weight of the liquid in the short arm, minus the same difference in the case of the longer arm.

Light, bulky bodies float in air or are borne up to a certain degree by the buoyant force depending on inequality of pressure at different depths. For this reason, a pound of feathers as weighed in air weighs more than a pound in a vacuum. A balloon may rise to a great height, because of its great volume of gas lighter than air. The highest ascent was that of Glaisher in 1861, who attained an elevation of over 36,000 feet.

Gases are absorbed by liquids and solids, the absorption in the latter instance being termed occlusion. The amount absorbed varies greatly for different gases, increasing with increase of pressure and decreasing with a rise in temperature.

By co-efficient of absorption is meant the amount of gas absorbed by one volume of a liquid at 0° C. and 760 mm. mercury pressure. The "law of partial pressures" is, that the solubility of each gas in a mixture is proportional only to its individual pressure. In other words, the absorption of each gas is independent of all the rest. In most instances the absorption is accompanied by feeble chemic action. Charcoal is a striking example of an absorbent solid, taking up 90 times its own volume of ammonia-gas. Water has great avidity also for ammonia, 1 volume at 15° C. dissolving 783 volumes of the gas.

Experiment.—Fill a dry cylinder with ammonia by driving this gas out of ammonia water with the aid of heat and collecting by upward displacement. Place the cylinder, mouth downward, in a vessel of water, and agitate slightly. Why does the water rise in the cylinder?

The sp. gr. of a gas can be ascertained by filling a thin glass globe with the gas and comparing its weight with the weight of the same volume of air, or, more frequently, hydrogen (density). Allowance must be made mathematically for differences in temperature and atmospheric pressure.

Three or more volumes of combining gases condense into two volumes.

Cardiac failure on going to high altitudes is due to sudden decrease in extracardiac without any corresponding decrease in intracardiac pressure, which remains about 760 mm., as shown by manometer. This difference leads to acute cardiac dilation. In estimating the pressure on the heart 6 mm. should be deducted for the tension required to overcome the elastic force of the air-cells.

Barometric Neuroses.—The total atmospheric pressure on the adult human body at sea-level is about fifteen tons. This pressure may vary a ton either way with weather changes, and so, through circulatory effects, take part in causing rheumatic pains, headache, drowsiness, and other barometric neuroses in susceptible individuals, particularly old people and others with lessened arterial elasticity. Hydroscopic variations in the tissues, due to changes in atmospheric humidity, may also play a part. Again, the relative rarity of the air, consequent deficiency of oxygen, owing to admixture with lighter water vapor preceding a storm, may lead to malaise and exhaustion, as in mountain ascents.

Temperature alterations, from the liberation of latent heat by condensation of water vapor to the liquid or solid form, and the heating and cooling of air currents by adiabatic compression and expansion, are likewise to be taken into account. Electric storms may excite severe general headache.

Concerning atmospheric electricity, small amounts of the positive variety are stimulating; of the negative (as in bad weather), depressing. These neuroses, says Weir Mitchell, may occur even in the outer limits of storm conditions. The rain or cloud areas may be 200 or 300 miles away, yet the sufferer be within the bounds of barometric depression.

HEAT.

Heat is molecular motion. Cold is a relative term, signifying merely a low degree of heat. The principal source of heat, both directly and indirectly, is the sun, although the earth receives only about a two-billionth part of the solar radiant energy. The sun clothes our planet with vegetable life, which is used largely for fuel, either in the primary condition of wood or transformed into coal, gas, and oil. The earth receives in sunlight ¼ horse-power for each square foot of surface (Dolbear).

The fixed stars furnish us with no small amount of heat. The interior of the earth is thought to be in a molten state (with a hard central core), as evidenced by volcanoes, geysers, and hot springs. The temperature increases as we descend into the earth: about 1° F. for every 50 to 100 feet. There is no seasonal change below 30 feet. Atmospheric temperature diminishes about 1° C. for each rise of 160 meters.

Mechanic friction, percussion, and pressure are common causes of heat. We rub our hands or a patient's body to make it warm. Some savage peoples still start their fires by revolving the sharpened end of a stick of wood in another dry piece. It is only about eighty-five years since the flint and tinder were supplanted by matches. A beautiful natural illustration of the development of heat by friction is seen in the "shooting stars," celestial bodies of low density, which become so intensely heated on passing through our atmosphere as to burst into consuming flame.

Artificial heat is produced generally by chemic action, especially by the oxidation (oxygen-combination) of substances rich in the elements of carbon and hydrogen, as are all ordinary fuels. The fermentation of vegetable substances may produce sufficient heat to give rise to spontaneous combustion. Carloads of ripe fruit have been known to become self-cooked in this way. Animal heat originates in chemic action, namely: the oxidation of carbon and hydrogen in the tissues.

Experiment.—Add some sulphuric acid to water, and note heat produced. Is this a physic or chemic change?

Substances contain a store of chemic energy or invisible motion inducing them to enter into combination. If heat is evolved in a reaction, a part of the chemic energy is so transformed. If heat is absorbed, it is rendered latent as chemic energy. According to the law of Hess, the thermal effect of any chemic change is the same whether the change consists of one phase or any number of separate phases.

Transmission of Heat.—This occurs in three ways: by conduction, by convection, and by radiation. Conduction is transmission by continuity from one portion of a body to another, as when an iron poker grows gradually hot from the end which is in the fire to the opposite extremity. Different substances vary greatly in the facility with which they carry heat. Metals, as a rule, are good conductors. Wood is a poor conductor; hence is used for the handles of iron culinary vessels. Air is also a poor conductor. Woolen clothing is warmer in winter and cooler in summer than other fabrics, because of its loose texture. The air it contains in the pores prevents the inward passage of heat to the body in summer and the outward passage of body-warmth in winter. Poor conductors are employed to a large extent for packing purposes to prevent freezing or thawing. Examples of such uses are sawdust for ice, straw for cellars, and asbestos for water pipes. Gutta-percha and zinc-oxid cements are poor conductors, and are commonly employed to protect the pulp before filling a cavity with a dental amalgam alloy. The body fat is a poor conductor.

Experiment.—To prove that water is a poor conductor of heat: Pack powdered ice or snow firmly at the bottom of a test tube, and boil the upper portion of the water above. The ice or snow does not melt. Copper is 500 times better conductor of heat than water.

In convection heat is diffused by currents of liquids or gases, the warmer portion of the fluid rising while colder streams, being heavier, descend to fill the vacated space. Ventilation, the renewal of air in mines and buildings, is accomplished by convection, a double current of warm and cool air being established by reason of the difference of temperature inside and outside the inclosed space.

Experiment.—To show convection in fluids: Boil some colored anilin in water in a beaker.

The transmission of heat by spheric wave-motion through the ether or the air is called radiation. This is the manner in which the radiant energy emitted by the sun comes to us. Non-luminous bodies also radiate heat with varying rapidity, a stone faster than leaves or grass, and these more quickly than water. Radiant rays are either reflected, absorbed, or transmitted. Polished surfaces are good reflectors of heat as well as of light. Dark, rough surfaces greedily absorb radiant energy; hence become quickly heated. Well-blackened stoves radiate more heat. Transparent and diaphanous substances generally transmit heat with little loss, and are therefore hardly affected themselves as to temperature. They are diathermous to solar heat, but more or less athermous to the slower waves radiated back from the earth; the principle of greenhouses.

Rock salt and sulphur are very transparent to radiant heat. Copper sulphate is quite athermous to solar heat, and hence is used as a filter when treating skin lesions with sunlight. The top of a mountain, though nearer the sun, is much colder than the base, because of the lesser amount of soil to absorb the heat, and because the air itself retains scarcely any of the radiant energy which passes through it. The difference in temperature between direct sunshine and shadow is accounted for by the presence or absence of solar radiant heat, just as pulling down the window curtains cools a room.

Effects of Heat.—The manifold effects of heat are all manifestations simply of the enhanced motion of the molecules. It is this quickening of molecular movements which constitutes heat the repellent force, the antagonist of cohesion. Heat expands and cold contracts. The principal exception to this rule is water, which expands one-tenth on changing to ice with a force of 30 pounds to the square inch. Sulphur, cast iron, and type metal expand on cooling. White fibrous tissue (ligaments) expands and relaxes under the influence of heat; yellow elastic tissue, like rubber, contracts. Gases expand and contract equally and uniformly; liquids and solids unequally. The co-efficient of expansion in liquids usually increases with the temperature. Water increases $\frac{1}{20}$ in bulk from f.p. to b.p.; mercury, $\frac{1}{55}$. The action of applied heat is a double one: raising the temperature and changing the state of the substance acted on.

Temperature, or sensible heat, is the direct manifestation of heat to our senses. We say that a body is warm or cold, meaning that it gives off heat to our hands or takes it from them. If a cup of boiling water is let stand on the table, it radiates heat until it is of the same temperature as the surrounding air.

For the exact measurement of temperature (intensity, not quantity, of heat) we use instruments called thermometers, first invented in 1609. These consist essentially of a closed glass tube containing mercury, with a reservoir-bulb at the bottom and a scale of degrees. Heat expands the mercury, causing it to rise in the tube; cold has the opposite effect.

There are three graded thermometers in use, the Celsius, or centigrade; the Fahrenheit, and the Réaumur. The first named is the one employed by scientists the world over; the second is the ordinary household instrument; the last is now used only in Russia, Sweden, and Denmark. The centigrade scale is to be understood as being used in this book whenever it is not stated to the contrary.

Each thermometer-tube is first filled with mercury, which is boiled, and then the glass is sealed. To mark the scale two standard points are furnished by Nature, that of boiling water, or steam (the boiling-point), and that of freezing water, or melting ice (the freezing-point), or equal weights of snow and ammonium chlorid. The bulb of the instrument is placed in melting snow and then in steam, and marks are made corresponding to the summit of the mercurial column in each case. All that is left to be done is to divide the intermediate space into degrees of equal width: 100 for the centigrade, 80 for the Réaumur, and 180 for the Fahrenheit instrument. The part of the tube above boiling-point and that below freezing-point are divided in the same way into degrees. In numbering degrees the f.p. in both Réaumur and the centigrade scales is marked 0°; b.p. 100° C. in centigrade, 80° R. in Réaumur. The b.p. of the Fahrenheit scale is numbered 212° F.; f.p. 32° F., the zero in this scale being thus 32° below the f.p. of water, representing—the inventor mistakenly thought—the coldest attainable temperature. Water boils at 211° F. in a rough iron vessel, and several degrees higher in a very smooth vessel. It freezes below zero when very still, and when at or below the freezing-point may congeal *en masse* when its container is slightly shaken.

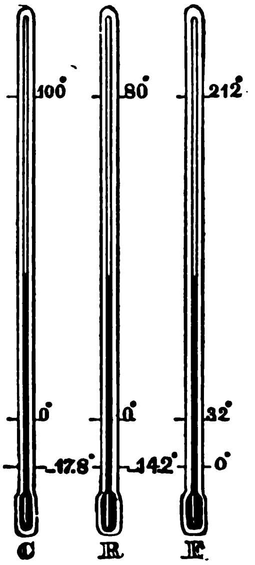


Fig. 9.—Comparison of Thermometer Scales.

Since 100° C. equals 180° F., it is evident that to change centigrade degrees into Fahrenheit degrees we must multiply by $^{180}/_{100}$, or $^{9}/_{5}$; and to convert F. degrees into C. degrees we multiply by $^{5}/_{9}$. One other thing needs to be taken into consideration, namely: that the F. zero is 32° below f.p. Therefore, to convert a centigrade reading into the F. scale we should multiply by $^{9}/_{5}$ and add 32°; whereas the reverse operation requires that we first subtract 32° and then multiply by $^{5}/_{9}$. Since Hg freezes about — 40° and boils at 357¼°, some other substances must be used for the extremes beyond these points. Alcohol (colored) thermometers are employed for very low temperatures (alcohol freezes at — 130°), and bars of platinum measure by expansion very high temperatures; no two solids have the same rate of expansion. Pyrometers are instruments for measuring temperatures above the b.p. of mercury. They depend on electric changes induced by heat or on expansion of gases. Thermoscopes show thermal variations by changes in the volume of vapors. Langley's bolometer registers accurately a change in temperature of less than one-millionth degree, by lessened resistance and increased current with cold in a platinum wire in an electric circuit connected with a galvanometer.

The figures given above refer to the b.p. of pure water at sea-level. A rise in altitude, by decreasing the amount of atmospheric pressure, lowers the b.p. at the rate of 1° C. for every 960 feet of ascent above the sea-level. The altitude of any place may be easily ascertained by applying this fact. When water is heated under more than ordinary atmospheric pressure, the b.p. is raised and the digestant action of the fluid much increased.

Experiment.—The culinary paradox: Fill a glass flask one-third full with water, and heat till boiling thoroughly, then cork tightly and invert the flask. Ebullition quickly ceases. Why? It begins again and continues if cold water is poured over the flask. Why?

Experiment.—By means of a flask and a thermometer take the b.p. of water and estimate altitude. The thermometer, loosely incased in a wide tube, should be introduced into the vapor-chamber so far that correction for the projecting thread of mercury may be neglected. Bumping is prevented by throwing in small pieces of some porous substance, such as talc or pumice.

The effect of pressure upon the f.p. (or melting-point) is obviously to lower it (make the change more difficult) in substances—water, for instance—which expand on solidifying. Examples are a snowball and the track of ice made by a sled in the snow; the f.p. rises when the pressure is removed. On the other hand, pressure aids (raises the f.p.) the solidification of liquids which contract on passing into the solid state. The presence of solids in solution renders freezing and vaporization both more difficult, and hence raises the b.p. (lowers vapor tension) and lowers the f.p. Examples of this fact are the use of salt on icy car-tracks and the making of ice-cream. Water saturated with common salt has a b.p. of 109°; with K_2CO_3, 135°; with $CaCl_2$, 179°.

Raoult's law is to the effect that the lowering of the f.p. of an aqueous solution below the f.p. of pure water is proportionate to the number of molecules (and ions) dissolved in the unit of volume of the liquid, whatever be the nature and weight of the molecules.

The b.p. of other liquids is not the same as that of water. Pure anesthetic ether will boil in the hand in a test tube, when a few pieces of broken glass are added. Mercury changes into a gas at 357°. Ammonia volatilizes from its liquid form at about the same temperature at which mercury freezes, namely: —40°.

Experiment.—Find b.p. of alcohol.

The f.p., or solidifying-point, of most liquids is identic with their melting-points when in a solid state. Melting ice and freezing water, for example, have precisely the same temperature. The most infusible metal is iridium, which melts at 1950°; and next to this comes platinum.

Medical thermometers are made self-registering by a constriction of the lower part of the tube, which permits the passage of the liquid upward in small drops under the greater force of heat, but causes a break when contraction begins, gravity not being sufficient to force the mercury downward. The same principle is utilized in the maximum meteorologic thermometers. The minimum meteorologic thermometers contain alcohol and an index of black glass, which is sucked down by capillary attraction between it and the alcohol, and remains at the lowest level reached by the column of fluid in the tube. These two varieties are also called recording thermometers.

Thermometers that have been used for a long time are likely to give slightly higher readings, owing to the crushing in of the glass at the bulb by external atmospheric pressure, the space not occupied by mercury having been made a vacuum. Thermometers should be seasoned for at least a year before marking, in order to let the glass reach its ultimate stage of contraction after the heating it has undergone.

The absolute b.p. is the temperature at which a liquid heated in a sealed glass tube is changed to vapor. That of ether is 190°. If a few drops of a liquid are let rise through the mercury of a barometer tube, they evaporate as soon as they reach the upper surface, by their vapor tension or pressure causing the quicksilver to fall until the space is saturated with the vapor. The boiling of a liquid occurs at the temperature which raises the vapor tension to a point equal to the atmospheric pressure. The maximum vapor tension is constant for each liquid at a certain temperature, being much increased by heat. In the absence of air water can be superheated above 100° without ebullition, or can be cooled to — 20° without freezing, but solidifies at once (metastable) on contact with ice. When two liquids are soluble in each other, the vapor pressure of the solution is much less than the sum of the separate tensions. If they mix in all proportions (as alcohol and water), the v.p. is intermediate between those of the two constituents.

Specific Heat.—Not all substances become heated with equal rapidity. The water in the tea-kettle is cool after the iron is heated, and remains warm after the vessel and stove have cooled. Except the gas hydrogen, water has the greatest capacity for heat of any substance; that is, it requires more heat to warm it and gives out more heat in cooling than anything else except hydrogen. For this reason a coast climate is more equable than inland weather; in the night the heat of the slowly cooling ocean flows over to the land, while by day the water draws off warmth from the rapidly heated sand and soil. The ratio of the capacity for heat of any substance as compared with an equal weight of water is termed its specific heat. Mercury, for instance, becomes heated 30° while the same weight of water rises only 1° in temperature. The specific heat of mercury is therefore 0.0333. That of iron is 0.1138; of air, 0.2375; of ice, 0.5040; of the human body, 0.9. Every substance has its own specific heat, which increases with temperature: more in liquids, except water.

Experiment.—Put on each side of a double porcelain vessel equal weights of water and mercury, and heat as equally as possible. Compute the specific heat of the liquid metal.

Atomic heat is a constant, approximately ranging from 5.39 to 6.87. It varies with allotropic forms and different temperatures, falling outside of these limits. The specific heat of any element equals its atomic heat divided by its atomic weight.

Liquefaction.—This signifies the change from a solid to a liquid state. It takes place for each substance at a particular melting-point, which remains the same until all the body has been liquefied, when the temperature again rises. As already stated, the melting-point is, for the same substance, ordinarily the same as its f.p. Iron and glass have no true fusing-point. When a change of condition can take place in either direction, we have what is termed a reversible cycle. Animal and vegetable substances are generally decomposed without liquefying on heating sufficiently. Certain alloys melt at a lower temperature than boiling water, and are used extensively in automatic fire-extinguishers. The heat of fusion signifies the quantity of heat, measured in calories, which is required to melt 1 gm. of the substance. The heat of solidification is the quantity of heat set free when 1 gm. of a substance is changed to the solid state.

Evaporation.—The slow and natural vaporization of water that takes place continuously from the surface of the globe is termed evaporation. The rapidity of evaporation varies directly with temperature, atmospheric dryness, and extent of surfaces of water and air exposed to each other; it varies inversely with atmospheric pressure. Chemists employ wide and shallow vacuum vessels for evaporating purposes. We have all experienced the oppressive discomfort of damp, sultry days when the air contained already as much water-vapor as it could, and hence the cooling process of evaporation from the skin was greatly impeded. It is easy to see that the sensible temperature need not correspond at all with that shown by the thermometer.

Very high temperatures are easily endured when the air is dry, whereas, if the atmosphere is moist sunstroke or heatstroke is liable to occur. The changes in atmospheric temperature induced by expansion (cooling effect) or contraction (warming effect) are termed adiabatic. High altitudes are generally dry, because the colder air tends to condense the moisture continually and precipitates it in the liquid or solid state, leaving but little present as vapor in the atmosphere.

A rise of 10° C. nearly doubles the capacity of the air for moisture(5.4 gm. to a cubic meter at 0°), but evaporation goes on, though much more slowly, even below the f.p. In changing from the liquid to the gaseous state great expansion takes place; a cubic inch of water becomes a cubic foot of steam. The student should remember that water when evaporated is taken up, not as a liquid, but as a vapor, which mixes with the air just as other gases do. The only distinction between a vapor and other gases is that the former condenses readily into the liquid form, while the latter do not. By critic temperature is meant the degree above which a gas cannot be reduced by pressure to the liquid form. The critic temperature of air is — 194°; of water-vapor, 400°. Aeriform bodies are termed gases above their critic temperature; vapors, below this point.

The capacity of air for heat depends chiefly upon the proportion of water-vapor it contains. This fact makes a difference of about 30° F. between sun and shade in the dry Rocky mountain regions; in Death Valley, Cal., a difference of 122° F. and — 73° F. has been recorded.

When air contains so much water-vapor that the least lowering of temperature would precipitate the latter in the liquid or solid form as dew, fog, mist, clouds, rain, hail, or snow, the air is said to be saturated, and the temperature at the time is called the dew-point. The air seems dry if its temperature is much above the dew-point; moist, if the temperature and the dew-point are nearly or quite the same. The air of a furnace-heated room contains more total water-vapor than does the cold air outside; but relative to the dew-point and to our sensations the outer atmosphere is humid, the inner dry. The relation of the temperature to the dew-point at a given time is usually expressed in the meteorologic reports as percentage of relative humidity. Air containing less than 40 per cent saturation feels dry; above 80 per cent, moist.

The hygrometer is a simple apparatus for estimating the relative humidity of the atmosphere. It consists of a glass tube filled with water and fitted with a wick, which covers and keeps constantly wet the bulb of one of two thermometers placed side by side. Evaporation of moisture from the wick cools the mercury underneath and lowers the temperature of this thermometer.

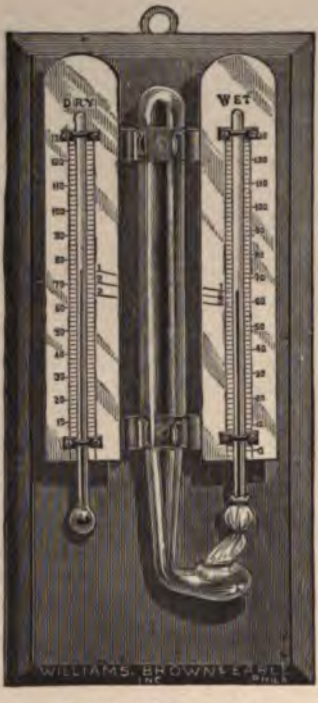


Fig. 10.—Hygrometer.

The dryer the atmosphere, the greater the difference in readings of the two thermometers. Sensible temperature is that of the wet-bulb thermometer, and is usually about 10° F. less than the dry bulb in Colorado; much less difference near the sea-coast.

Dry air expands upon taking up moisture, and the weight of a cubic foot of saturated air is less than that of the same volume of dry air, despite the weight of the water vapor (5.77 grains per cubic foot at 60° F.).

Distillation.—Artificial vaporization is used principally for the purification or separation of water and other liquids. It is conducted at the b.p. of the liquid distilled in an apparatus called a still. This consists essentially of a retort, or flask, in which the substance is boiled, and a condenser. The latter is a long glass or spiral copper tube connected with the retort and surrounded by a vessel or a larger tube in which cold water is kept running. The cold water condenses the passing vapor into drops, which run out at the lower end of the condenser. Copper condensers should be tinned on the inside.

Experiment.—Distill colored water, using a flask connected with a Liebig condenser, and catch the colorless product in a beaker.

By fractional distillation is meant the separation by volatilization of one liquid from another, or of several from each other. It depends on different liquids having different b.p.'s. To distill alcohol, for example, from a mixture of alcohol and water, such as wine, the liquid is heated only to the b.p. of alcohol, which vaporizes, leaving most of the water behind. Destructive distillation is a term applied to the vaporization, with chemic decomposition, of solid substances, such as wood.

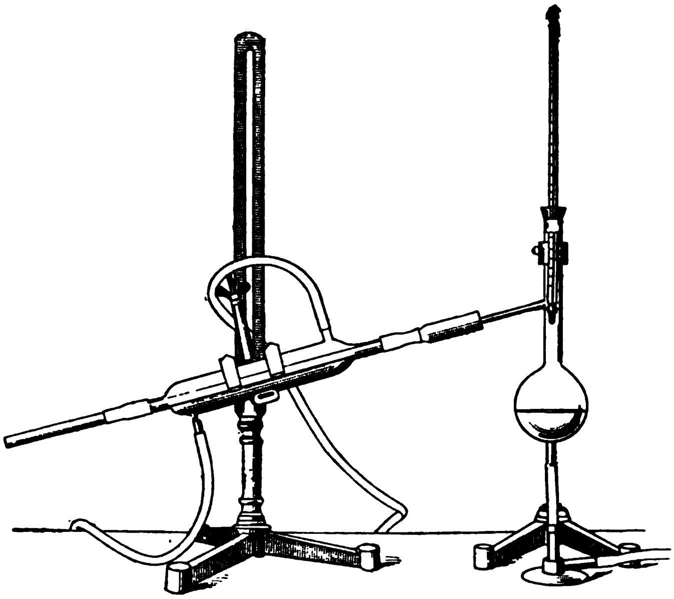


Fig. 11.—Apparatus for Distillation.

The amount of vapor formed from a liquid at its b.p. in a closed vessel is the same whether the vapors of other substances are present or not. This is one proof of the existence of intermolecular spaces.

Sublimation.—The direct transformation of a substance from the solid into the gaseous state is called sublimation. Iodin, sulphur, camphor and corrosive sublimate are examples of sublime substances. The process of sublimation is used mainly for purifying purposes, and is sometimes repeated (resublimation). It depends on the vapor pressure of solids, and the point of sublimation is usually above that of fusion.

Experiment.—Heat impure ammonium chlorid in the bottom of a large test tube; watch it sublime and collect in pure, white, crystalline masses in the upper part of the tube.

Solution.—Solutions are homogeneous mixtures of two or more elements or compounds which cannot be separated mechanically. In the case of colored glass and crystals, we may speak of a solid solution. Heat aids the solution of solids in liquids, but interferes with the absorption of gases. The process of solution is not thoroughly understood, but probably consists in a change similar to fusion, followed by mechanic admixture. When a solid substance dissolves in a liquid without the application of heat, the necessary heat is taken from the liquid itself, cooling it accordingly. If, however, chemic reaction predominates, the liquid becomes warmer. A physic solution, therefore, is marked by a lowering of temperature; a chemic, by a rise in temperature. The solution of a gas in a liquid raises its temperature. Hygroscopic substances in general give rise to heat on dissolving in water.

Experiment.—Make a saturated aqueous solution of potassium iodid. Is it cold or hot?

Experiment.—Dissolve a little quicklime in water. Is it hot or cold?

A liquid which dissolves solid substances is said to be a solvent for them. Water is the best solvent for a great proportion of drugs and medicines; alcohol comes next in dissolving power; then ether, chloroform, turpentine, and fixed oils. Percentage solutions are usually by weight.

When solids are dissolved in liquids, their molecules obey the same laws of diffusion and pressure as those of gases. In general, those substances are most soluble whose surface tension is least. The solubility of any substance (solute), in a solvent is always the same at the same temperature, which for convenience is stated at 15° or 25° C. in the tables of solubility. Different substances vary greatly in their solvents and their solubility. Some are so soluble in water that they absorb moisture from the air and become liquid. Such bodies are called deliquescent or hygroscopic. The opposite property of becoming dry when exposed to the air is termed efflorescence.

When a solvent can take up no more of a substance it is said to be saturated; if it can take up a little more, the solution is concentrated; if it can take up a good deal more, the solution is dilute. Saturated solutions are prepared by long agitation with the required salts, then tested for supersaturation by bringing in contact with well-developed crystals of the same salt.

A solution saturated with sodium sulphate at a higher temperature remains supersaturated on cooling, if undisturbed.

A saturated solution of one substance does not prevent the taking up of any other solid and may even aid such an occurrence. The total amount of two or more substances capable of being dissolved is always greater than that of any one alone, though usually there is less of either than if it were dissolved alone. Solutions of compound salts, such as carnallite, contain different proportions of the constituent salts, varying with temperature. There is a constant ratio (co-efficient of distribution), in the amount of a substance dissolved by each solvent, when shaken with two immiscible solvents.

Experiment. — To a solution of mercuric chlorid add excess of potassium iodid. The red mercuric iodid is first precipitated, then redissolved. Potassium iodid is also employed to aid the solution of iodin in water. A little cane sugar makes borax more soluble in water. Antipyrin renders quinin soluble in water, so that the latter may be given hypodermically.

A practical knowledge of the solubility of common drugs is necessary to physicians in prescribing liquid mixtures. Water is the solvent to be chosen for most mineral and alkaloidal salts, gums, sugars, albumins, gelatins, and solid acids. Alcohol is the solvent for resins, gum-resins (dilute alcohol), balsams, volatile oils, and stearoptens. Ether dissolves fats and fixed oils. Glycerin is a ready solvent for earthy salts (alum, borax) and tannin. Fixed oils dissolve sulphur and phosphorus. Carbon disulphid is a good solvent for sulphur. Chloroform dissolves gutta-percha. Turpentine is a solvent for paints, fats, fixed oils, and sulphur. Mercury dissolves nearly all metals except iron and platinum.

A solution of a non-volatile inorganic substance in water is called a liquor; of a volatile or gaseous, an aqua. Most aquæ are prepared by triturating the medicinal agent with purified talc (or precipitated calcium phosphate) and adding water gradually, then filtering to remove the insoluble powder. Aqua hamamelidis (prepared by distillation) contains 15 per cent. alcohol. If, instead of simple water, the solvent used is a concentrated aqueous solution of cane-sugar, we have a syrup. Infusions are preparations made by treating vegetable substances with cold water; decoctions are similar, but hot water is used instead of cold.

Tinctures are alcoholic solutions of non-volatile (iodin excepted) principles of drugs; spirits are solutions in alcohol of volatile medicinal agents; essences are stronger spirits.

Soluble substances are, as a rule, more soluble in hot than in cold water or other liquid. In case of a chemic solution, however, such as that of quicklime in water, the reverse is true, as there are in cold water more molecules present to enter into chemic combination than in the same volume of warmer water.

Experiment.—Heat limewater to boiling, and note turbidity, which clears up on cooling.

Common salt is about as soluble in cold as in hot water. Sodium sulphate is most soluble in water at 33°. The process of solution is aided also by pulverizing the substance to be dissolved, thus rendering it more easy of access to the molecular attraction of the menstruum. Other means of hastening solution are shaking the vessel and trituration of the solid with the liquid.

Sediments or precipitates are separated from the liquid and soluble portion of a mixture by filtration through unsized paper, glass-wool, asbestos, etc. Porous solids, such as charcoal, absorb coloring matters, and are used in decolorizing filters.

Colloidal solutions are probably suspensions, and do not diffuse through parchment paper. They reflect incident light polarized, and colloids move under the action of an electric current (cataphoresis), some to the negative and others to the positive pole. They are precipitated by electrolytes (ions) having an opposite charge. One colloid may precipitate another by absorption (surface attraction, as of charcoal for colors or of ferric hydroxid for arsenic). The colloids in beer enable it to hold much more carbon dioxid than a corresponding mixture of alcohol and water.

When fluids mingle together physically they do so in no definite proportions. Fluids immiscible with water are held in suspension by the aid of some viscid excipient, as acacia, soap, gums, and white of egg, or in the form of soap with an alkali. Emulsions separate spontaneously on standing for a longer or shorter time, in this way also differing from true solutions, which are broken up only by the formation of crystals.

Divers Effects of Heat.—Heat aids chemic changes by increasing the space between the molecules, which are often decomposed into smaller ones. Organic molecules, being larger than inorganic ones, dissociate (are broken up) at a lower temperature (majority at 200° C.) than the latter, which, as a rule, can sustain heating to more than 1000° F.

Another interesting effect of heat is change of color. Orange-red antimony sulphid turns black on drying thoroughly. Mercuric iodid changes from scarlet red to orange-yellow on heating, becoming red again on cooling. Mercuric oxid at a very low temperature (— 200°) fades from scarlet to pale orange. Yellow chromates turn red on heating.

Experiment.—Heat a little zinc oxid in a test-tube over the flame. It becomes light yellow, turning white again on cooling.

Heat generally improves the malleability and ductility of metals. Most metals and solid compounds become brittle with great cold.

Thermotherapy.—Superheated air (300°-400° F.) is employed in special apparatuses, lined with asbestos or sectional magnesia, to relieve pain and reduce swellings, particularly in relation to the joints. The hot-air chest must be free from all moisture, lest scalding ensue, the perspiration being absorbed by blankets or flannels that invest the limb or body.

Free diaphoresis, by means of hot air passed under the bedding from a spirit lamp at the lower opening of an elbow tube, is about the most effective means of relieving uremic symptoms, especially when preceded by an alcoholic stimulant and pilocarpin. Care should be exercised not to pass the hot current directly against the naked skin, lest painful blistering result. The hot bath, the vapor bath, the Scottish douche, the shower bath, and other forms of hydrotherapy depend for their value chiefly on the great capacity of water for holding and transmitting heat or cold.

In the bath, the body temperature rises 1° F. for each 20° F. higher external temperature. The amount of moisture thrown off from the body, says Kellogg, is increased 50 per cent. or more by using friction. General hot applications diminish the alkalinity of the blood, often doubling the amount of acid phosphate therein. Urinary acidity is diminished (even rendered alkaline) by warm baths. Heat causes increased activity of the leucocytes, while ice-applications to affected parts in localized maladies depress the vital activity of the germs. Heat and fatigue, alike, produce an accumulation of unoxidized poisonous products with properties like those of curare.

Latent Heat.—We have already seen that a solid body when heated sufficiently rises in temperature until its melting-point is reached, when the temperature remains stationary (if crystalline; still rises more or less if amorphous, like sealing wax) until liquefaction is complete, and then rises to the b.p., at which temperature the liquid stays until it is entirely vaporized. The heat which is used up thus in overcoming cohesion and changing the state of a substance is called by the rather misleading name of latent (hidden) heat. When a gas becomes again a liquid or a liquid a solid, all this heat is given out again as temperature. Steam-heating depends on this principle; the vapor, being condensed in the pipes, gives off its latent heat. We are familiar with the usual warm and sultry feeling preceding a storm, this feeling being due to the giving off of latent heat during condensation of water-vapor. Latent, or insensible, heat performs a very important part in the mutations of the seasons, moderating sudden changes both of thawing and of freezing.

Change of material form always implies the presence of heat, and this heat is abstracted from the nearest convenient source. We cool a room or a street by sprinkling water on the surface; to change the water into vapor, heat is taken from the air. The sudden expansion of the confined gas when a bottle of light wine or beer is opened reduces the temperature in the neck of the flask so much that a fog appears in it. Artificial ice is made on the same principle by the expansion of liquefied ammonia, carbon dioxid or sulphur dioxid, into gas in vacuum apparatus arranged in tanks filled with water, the cooling action being aided by the use of brine, into which cans of water or cooled metal plates are immersed. The complex but definite solid produced by freezing a saturated aqueous solution has been termed a cryohydrate. Refrigerator cars are double-lined and contain cylinders of closely packed ice and salt.

Freezing mixtures depend on the utilization of heat in one or more of three ways, namely: by evaporation, by solution, and by expansion of gases. Considerable cooling is also effected by radiation. Drinking-water in warm countries is kept cool by placing it in flat vessels on straw or in porous water jugs. The lowest temperature yet attained is — 263°.

Experiment.—Spray ether on the hand, or dip a thermometer for a moment in this liquid, and note how many degrees the temperature is lowered by the time the instrument is dry.

Experiment.—Mix some ammonium nitrate with an equal volume of water, and note effect. A mixture of 5 parts saltpeter, 5 ammonium chlorid, and 19 water lowers temperature 22°.

Just as heat can be produced by mechanic energy, so again it can be transformed into the latter. Stationary and locomotive steam-engines, hot-air and gas-engines are illustrations. All of these depend on pressure due to the expansive force, or tension, of matter in the form of gas.

Calorimetry.—Calorimeters are instruments designed to measure the quantity of heat in substances. There are four methods of calorimetry: By fusion, volatilization, and warming water or cooling. For instance, the ice-calorimeter consists of a block of ice with a cavity closed by a cover. The body to be tested is placed at a certain temperature in the cavity and left there until it has cooled to 0°. The quantity of water produced by the melting of the ice in the cavity is then weighed, and the relation between cause and effect expressed in heat-units. Again, the quantity of heat in a body can be readily measured by plunging it into a certain quantity of water at a known temperature and noting the number of degrees the water rises.

Thermal Units.—The amount of heat required to raise the temperature of a kg. of water 1° C. is called a greater calorie (C.); to raise 1 pound 1° C., a thermal unit. One calorie equals 2.2 thermal units. A lesser calorie (gram-calorie, c) is the amount of heat required to raise one gram of water 1° C. To convert greater, or kg., calories into pound F. heat units, multiply by 4, and *vice versa*.

If we mix a kg. of water at 79.2° with the same weight of pounded ice at 0°, the water will dissolve the ice, and the temperature of the resulting liquid will be 0° C. Stated briefly, 79.2 calories are required to convert ice into water. In changing the water into vapor 535.9 calories are used up. In other words, it takes more than five times as long (temperature of flame stationary) to "boil away" a given quantity of water as to raise its temperature from f.p. to b.p.

Hydrogen has the greatest heat of combustion, 1 gm. on burning producing 34,200 calories.

Carefully performed experiments by the English physicist Joule have established the fact that the amount of heat necessary to raise the temperature of a pound of water 1° F., when transformed into mechanic energy, is equal to 772 foot-pounds, or for 1 kg. 418 kgm. This number, therefore, is termed the mechanic equivalent of heat, and is usually expressed by the abbreviation J. When electric energy is converted into heat, one gram-equivalent at one volt tension yields 23 calories. The Carnot-Clausius principle is to the effect that, in a reversible cycle, the sum of the quantities of heat divided by the absolute temperature at which it is given off is equal to zero.

LIGHT.

Light is that form of radiant energy which gives rise to visual sensations. It is believed to consist in vibrations of ether, a continuous, imponderable, transparent, structureless, infinitely tenuous, perfectly elastic, frictionless, rigid, and incompressible body filling all space, whether apparently vacant or occupied. This hypothetic ether is the great medium of transfer of energy: of gravitation as well as of molecular and atomic forces. Indeed, there are not wanting eminent physicists who hold that ether is the only true matter, and that molecules and masses perceptible to our senses are but varying combinations of ethereal vortex rings: in other words, of ether in motion.

Rays and Waves.—Of the multitudinous waves that constantly flow and break throughout the universe, only a comparatively small number are perceived by the unaided senses. Light waves range in length from 380 (violet) to 810 (red) micromicrons. Heat waves are longer (up to 70,000 micromicrons), and still longer are the electric waves ($\frac{1}{10}$ inch to 600 feet), the longest of all being the Hertzian waves produced by sending a charge of electricity across a gap, and which are utilized in wireless telegraphy. These are much longer than the air-waves of sound, which seldom exceed a few feet in length. The chemic or actinic waves of radiant energy, and the X-rays, cathode rays, N-rays, etc., are shorter and more rapid than those of light. The X-, or tri-ultraviolet (Satterlee) rays have, according to Weidemann, a wave-length of 0.014 micron, while the ultraviolet, or cathode, waves are 0.21 micron in length.

The radiations from radio-active substances are held to consist of particles of matter hurled from their compounds with enormous velocities. The beta rays from radium are supposed to have a velocity about half that of light; alpha rays, one-tenth. The Becquerel rays are a mixture of X-rays, positive particles, and cathode rays given off from uranium and other metals. They affect photographic plates in the dark.

The X-rays differ from the ultraviolet rays in not being subject to reflection, refraction, or polarization. X-rays discharge an electroscope either positively or negatively electrified; ultraviolet, negatively only. Both kinds of rays excite a bright green fluorescence in willemite, but with calcium polysulphid X-rays cause a white, and ultraviolet rays a blue, phosphorescence. Rock salt is opaque to the X-rays; transparent to ultraviolet rays.

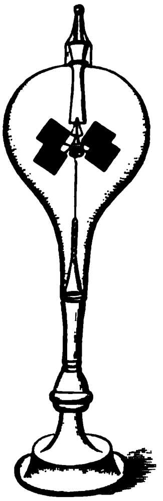


Fig. 12.—Radiometer.

Cathode rays are thought to be negatively charged corpuscles. They can be deflected by a magnet. The beautiful Geissler light, obtained by passing an electric discharge between metal discs at opposite ends of a nearly exhausted tube, consists of particles (electrons) about $\frac{1}{1000}$ the mass of a hydrogen atom, and traveling at great velocities. These rays are identic with the beta radium rays.

Niewenglowski's rays is the term applied to the phosphorescence shown by various calcium salts after exposure to sunlight. The N-rays (from the town Nancy) of Blondlot, given off from Welsbach burners, form a connecting link between ordinary light and the emanations of radioactive metals, and are the same as the physiologic radiations from the human body, discovered by Charpentier.

The radiometer consists of a hollow glass sphere on a stand; the sphere is nearly a vacuum, containing about a millionth of an atmosphere: the so-called radiant matter. Within the globe are four little vanes, of mica, bright on one side, dark on the other, and suspended on a platinum support so as to revolve easily when brought into the sunlight or near a flame. The revolutions are due to the difference in force with which the light-waves act upon the two sides of the vanes, being absorbed most by the blackened surfaces.

Experiment.—Show presence of heat in the solar rays by lighting a piece of oiled black paper with a burning-glass. A fire might be started in this way even with a lens of ice.

Experiment.—Show actinic effect of solar energy on a piece of white filter-paper dipped in a strong solution of silver nitrate, dried in a dark place, then covered with a wire gauze and exposed to sunlight.

Light travels always in straight lines, and its oscillations are at right angles to the plane of projection, like a rope shaken at one end. A ray of light is simply an imaginary line; a beam is a collection of rays, whether parallel, convergent, or divergent; a pencil differs from a beam only in its greater area. Light itself is invisible; a sunbeam in a dark room is not perceptible if free from dust.

A luminous body is one which emits light. An illuminated object is one on which light falls. Transparent or diaphanous substances, like glass, permit the free passage of light-rays. Translucent bodies allow some of the light to pass, but not enough to define distinctly objects on the farther side. Living bones are translucent to direct sunlight or electric light.

Opaque substances intercept all the light. Metals are opaque except in very thin layers, when they are translucent. A shadow is the contour projection of an opaque or translucent object produced by the stoppage of light.

The principle source of terrestrial light is the sun. Other sources of natural light are the so-called fixed stars, meteors, comets, volcanoes, and the lightning-flash. Artificial light is usually the result of combustion or of resistance to the passage of electricity.

The emission of light from a heated substance (above 1000° F.) without chemic action is termed incandescence; hence incandescent lamps (electric and Welsbach burners). Calorescence signifies nearly the same as incandescence; the heat-waves are converted into light-rays by concentration upon platinum or other metal. Fluorspar is highly pyroelectric, readily becoming luminous on heating. A "red heat" corresponds to about 1000°; "white heat" or Bunsen flame, to 1500° and higher; oxyhydrogen blowpipe, 2000°; the electric arc or furnace (boiling carbon) or acetylene blowpipe, 3500°. The explosion of cordite in closed vessels produces a heat of 5200°. The effective temperature of the sun is calculated at about 6000°.

By phosphorescence is meant the power of some substances to emit white or colored light, accompanied with little or no heat, under the influence of nervous, chemic, thermal, or mechanic stimuli, the effect persisting for some time after removal of the cause.

Experiment.—Stimulate some design painted with luminous paint (phosphorescent zinc sulphid) by burning a piece of magnesium ribbon before it. Then make the room dark and observe the phosphorescent glow.

Spontaneous phosphorescence is exhibited by fireflies and jellyfishes as the result of nervous energy; it is also seen in a solution of phosphorus, being due, in this instance, to slow oxidation; decaying organic substances, especially fish and the willow tree, often shine in the dark. Two pieces of loaf sugar rubbed together in the dark produce a phosphorescent glow. The sulphid and the cyanid of calcium are phosphorescent for some hours after exposure to the rays of the sun. Triboluminescent substances, such as quartz, diamond and willemite, emit light on being rubbed or struck.

From astronomic calculations, it has been determined that the solar light travels at the rate of 186,225 miles per second, a speed almost inconceivable; yet it takes 40,000 years for a ray of light to cross the visible universe. In water light travels three-fourths as fast as in air.

Light is reflected just as other forces are, the angle of incidence being equal at all times to the angle of reflection. The amount of light reflected is greatest when the illuminant is near the horizontal; least, when at the vertic meridian. A rough reflector diffuses or disperses the rays of light in all directions, and so reveals its own outline; a smooth surface reflects the rays without altering their relation to each other, and thus furnishes an image of the luminous object or of an opaque body placed between the latter and the reflector. A concave mirror converges parallel rays of light; a convex mirror has the opposite effect.

Images formed by actual union of reflected rays are termed real; when this union is apparent only and back of the mirror, they are called virtual images (plane, convex, and concave—with point of light between principal focus and mirror). The point in the axis of a mirror at which reflected rays meet is termed the focus. This is always half-way between the center of the mirror and the center of curvature: that is, the center of the circle which would be produced by prolonging the curve of the mirror. The kaleidoscope consists essentially of three plane mirrors with pieces of colored glass set in a pasteboard tube.

Refraction.—A ray of light in passing obliquely from a rarer into a denser medium (as from air to water) is bent toward the perpendicular; away from the perpendicular when traveling in the opposite direction. It is for this reason that an oar appears broken at the surface of the water, and that stars a little below the horizon are visible. The index of refraction is the ratio of the sine of the angle of incidence to that of the angle of refraction; for the same substances it is a constant quantity, except that in liquids the refractive power increases with density. The index of refraction from water into air is three-fourths; from air into water, four-thirds. Oil of cedar has the same refractive power as glass; hence is used with immersion lenses. The refractive index of the human crystalline lens is a little more than 1.4. The index of refraction (determined with refractometer) is utilized for the identification of oils and other organic liquids. It varies with the kind of light (nD = sodium light) and with the temperature. When the angle of refraction of an incident ray is more than a right angle (critic angle) with the perpendicular, the ray does not emerge, but is reflected; this phenomenon is called total reflection.

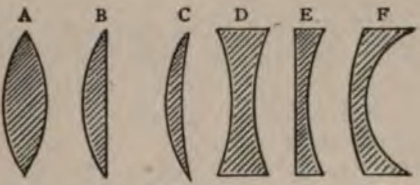


Fig. 13.—Lenses.

Experiment.—Look upward obliquely into a glass filled with water. Note that one cannot see beyond the mirror-like upper surface.

The mirage of the desert furnishes a beautiful example of total reflection, the image of trees and water beyond the horizon being reflected from denser strata of air at some distance above the surface of the earth. In the same way—that is, by difference in refractive power of its layers—air itself becomes visible, as when heated by a stove or the sun. The diamond is the most refractive of solids, and its brilliancy depends mainly on this property of internal reflection. Another example of total reflection is the camera lucida attached to the eye-piece of a microscope and used for sketching objects.

A prism is any transparent refractive body the sides of which form acute angles with each other. Prisms used in chemistry and medicine are termed lenses. According to form there are six classes of lenses, namely: convex, concave, plano-convex, plano-concave, concavo-convex (converging meniscus), and convexo-concave (diverging meniscus). Lenses which are thicker in the center converge rays of light; those which are thinner centrally have a divergent action. Convex glasses are used in spectacles for far-sight; concave ones for near-sight. A simple microscope consists essentially of a single convex lens. A compound microscope has two convex lenses; one is the object-glass, and the other in the eye-piece "magnifies" the enlarged image formed by the first lens. The objectives of good microscopes contain a combination of biconvex and plano-convex lenses.

The angle of aperture is the angle which the outer edges of the surface of the object glass make with a point in focus. Object glasses having a large angle of aperture have usually good resolving power. Lateral illumination can be arranged by placing a triangular prism under the microscope and holding an incandescent light near it, so as to get total reflection at the upper level surface of the prism.

Ultramicroscopy.—Helmholtz estimated the limit of microscopic visibility at 0.0001 mm. The new method of Siedentopf and Zsigmondy has reduced the limit to 0.000001 mm. In the mechanism invented by them, the illuminating ray is perpendicular to the axis of the microscopic objective, the focus of the condensing lens and of the objective being adjusted to meet at a common point. The source of light is sunlight projected by a heliostat into a darkened room, heat rays being removed by means of a quartz lens. The principle is the same as with a beam of sunlight revealing dust particles in a darkened room. The possible uses of the ultramicroscope in biology, bacteriology and physic chemistry are too obvious to need mention.

A telescope differs from a compound microscope in having a very large object-glass in order to catch as many rays of light as possible. An opera-glass contains a convex and a concave lens. The camera obscura of the photographer resembles the human eye in the presence of a convex lens in the front part of the instrument, and a screen sensitive to light at the rear. The image is reversed in both instances. The stereoscope has two lenses, each of which is plano-convex toward the center of the frame, and double convex in its outer part. The ophthalmoscope is a small, concave mirror with a central opening, behind which small lenses are passed until the examiner can see the retina distinctly. The Abbé condenser, used with the immersion lens and a plane mirror, is of two forms, double and triple. The double has a plano-convex over a biconvex lens; the triple contains a plano-convex, a concavo-convex and a biconvex lens.

Color.—In addition to their refractive effects, prisms disperse or break up white light into its component colors. The prism usually employed for this purpose is triangular and equiangular. The hues thus produced are infinite in variety, but seven colors stand out distinctly in the following order: Violet, indigo, blue, green, yellow, orange, red, the red being least refracted, the violet most. This dispersion of sunlight into the seven bands of the rainbow forms the solar spectrum. The violet waves are shortest ($\frac{1}{61000}$ inch) and most frequent (764,000,000,000,000 per second); the red waves are longest ($\frac{1}{36000}$ inch) and slowest (481,000,000,000,000 per second). The sensation of various color depends, therefore, on the number of wave-impacts of light upon the retina in a given second of time; difference in brilliancy depends on the relative force of the blows; direct sunlight is too dazzling for the human eye. The intensity of light, as measured by the photometer, varies inversely as the square of the distance from the luminous source (the surface of a sphere increases as the square of its radius), as also with the angle of incidence. The sun's light is only one-seventh as intense at 5° above the horizon as at the zenith. The earth is nearer the sun in winter than in summer, but the increased obliquity of the solar rays much more than offsets the decrease in distance. The intensity of a light is stated in comparison with the light of an English sperm candle burning 120 grains per hour. A color is said to be saturated when it contains no white light. White light, then, is composed of seven colors, which can be recomposed into white light by means of a biconvex lens. Two colors that, when taken together, produce white are said to be complementary to each other. Examples of such are purple and green, red and bluish green, orange and cyan-blue, yellow and ultramarine, yellowish green and violet. Complementary colors are the best for producing contrast-effects in dress or otherwise.

Experiment.—Make a weak solution of a nickel and of a cobalt salt. When mixed together carefully the pink and the green colors unite to produce a colorless fluid.

When we gaze at a certain color for some minutes the eye becomes fatigued for this hue, and if now we look at something white or into space we see, not the first color, but its complement.

The color of any object is not of itself, but of the light that it acts upon, absorbing, reflecting, or transmitting. In the dark everything is black. A red light gives a corresponding tinge to all objects in its path. Looking through green goggles, even the snow takes on the tint of grass. Red objects appear colorless when illuminated by the yellow sodium flame. Black represents the absence of all colors: that is, total absorption. A blue object is one which reflects or transmits to the eye only the wave-lengths of this hue. Transparent substances may have one color by reflected light, another by transmitted light; one may be the complement of the other. The color of fluorescent bodies is due to the absorbed waves.

Experiment.—Add to a beaker of water a few drops each of a solution of eosin and of hematoxylin. The mixture is green by reflected light, purple-red by transmitted light.

There are at least 1000 hues distinguishable by the human eye in the solar spectrum. Tints are produced by reducing a "pure" or "full" color (never above 75 per cent.) with white light. Shades are obtained upon viewing a full color in shadow, that is, by admixture of black. The colors of all natural objects are somewhat broken or subdued by light and shadow.

Water in large masses appears blue or green. The blue color of the sky is owing to the refrangibility of the violet rays being greater than those colors at the opposite end of the spectrum; hence when the sunlight floods the atmosphere, the bluish waves are bent down to us most of all. The red and yellow waves are longer and stronger than the blue, and to this are due the color-effects of sunrise and sunset, when the solar light must traverse a much greater layer of air than when the sun is nearer the zenith.

Mordants, such as salt, soda, alum, vinegar, and tin salts, fix a coloring agent by forming with it an insoluble gelatinous compound, which clings closely to the threads of textile fabrics. Wool holds dyes more fast than cotton, since the loose and fluffy texture of the former furnishes a greater surface for adhesion.

Iridescence is the name applied to the beautiful play of colors seen in cracks in glass, in soap bubbles, and in the plumage of birds and the lining of many shells. The phenomenon is produced by interference of secondary waves set up by thin films of air or by lines. Newton's rings illustrate color-effects due to interference by pressure. This apparent bending of the light-rays about lines and angles is known as diffraction. Diffraction-gratings are made of glass, the surface of which is ruled with fine lines very close together. They give a well-marked spectrum.

By fluorescence is meant the bluish opalescence seen in kerosene and other petroleum compounds, fluorspar, quinin solutions, eosin, fluorescein, platinocyanids, zinc silicate, and uranium salts. This appearance is due to the slowing of the ultraviolet waves in such a manner as to render them visible. Fluorescent substances (chlorophyl, for example), have the power of sensitization; *i.e.,* they change the energy of green and yellow rays to actinic rays. This principle is used in photography (orthochromatic plates).

Actinism.—Most chemic substances are acted upon to some degree by the actinic rays (blue, violet and ultraviolet) that accompany solar light. This is particularly true of silver salts, hydrogen peroxid, and of iodids of various metals. Actinic changes are prevented or retarded by keeping susceptible substances in dark or amber-colored bottles.

It is the chemic rays that produce sunburn (solar erythema) and freckles, by a protective stimulation of the melanin-containing pigment-granules of the rete mucosum. X-rays and the electric light, as well as the prolonged use of poultices and hot compresses, also stimulate pigment-formation. The bleaching effect of sunlight on dye-stuffs is likewise chemic in nature. Of the ultraviolet rays in sunlight, few if any reach the surface of the earth, being absorbed by the atmosphere. They cannot pass through glass. It is the actinic rays of sunlight that cause snow blindness, which occurs almost entirely at high altitudes, since the rare atmosphere here absorbs but few of these chemic rays. Electric light is especially rich in actinic rays, which may be shut off by the use of yellow glass.

Salts of silver are decomposed by light, with deposition of metallic silver, especially in the presence of organic matter; hence they stain the skin. Photographers employ sensitized plates and papers coated on one side with a film of collodion, albumin, or gelatin, containing an emulsion of silver chlorid, bromid, or iodid. The development of negatives is done in a dark room with some reducing substance, like hydroquinon, and then a fixing agent, commonly sodium thiosulphate, which dissolves the unreduced silver salt and fixes the metal. The photograph is obtained from the negative by exposing the latter over sensitized paper to direct sunlight.

Sodium sulphite preserves the hydroquinon or pyrogallic acid and prevents yellow staining. Sodium or potassium carbonate softens the film, so that the reducing agent can penetrate more readily. In the negative the objects photographed appear as colorless spaces on a dark background. In color photography the three principal colors of white light are spread in an emulsion of minute starch grains upon the glass or paper (positive or negative). At any given point the color ray from the object penetrates through the granule of the same hue, other colors being intercepted.

Spheric aberration is the term applied to the confusion of images arising from the difference in focus between the rays which penetrate the central portion of a lens and those that are refracted by its outer zone. This defect is best corrected by the use of a circular ring diaphragm, which shuts off light from passing through the edge of the lens. A good illustration of such a mechanism is the iris of the eye.

A small white object cannot be accurately focused on the retina by the crystalline lens, since, when the red rays are focused, the violet are not. This dispersion makes a bright object appear to be surrounded by a fringe or halo (irradiation), as seen in the incandescent film. Red objects appear brighter than those of other colors, because of the greater ciliary effort in focusing these longer rays.

Chromatic aberration results from the difference in refrangibility of the various color-rays. The violet come to a focus sooner than the others, and so give to the outer part of the visual field a disagreeable coloration. In microscopes the defect is overcome by combining a convex lens of crown glass with a concave meniscus of flint glass, constituting the achromatic lens, in which two of the three principal colors are brought to a focus. Apochromatic lenses contain also calcium fluorid, and bring all three colors to the same focus.

Phototherapy.—Sunlight is as essential to human beings as it is to plants. Both grow pale and weakly for want of it. The coloring matter of plants and of the blood is increased by exposure to the sun's rays. Sunlight is actively germicidal. Tubercle bacilli are destroyed by direct sunshine within a few minutes to hours. Light causes contraction of protoplasm.

Light stimulates the nerve-ends, and thus enhances nutritive activity. If a man is brought from darkness into the light, the carbon dioxid exhaled rises 14 per cent.; or, if the light is allowed to act on the whole body, the increase amounts to 36 per cent. Sunlight is capable of penetrating the entire thickness of the body, as has been proved by developing photographs through the chest. Blue light enhances metabolism and has a strong absorbent and anodyne effect.

The chemic rays of light are sedative and strongly bactericidal, and have been used successfully in treating lupus, cutaneous cancers, and other chronic skin diseases. While making the application, the tissues are dehematized by pressure, to permit greater penetration of the rays.

In the Finsen method the heat rays from a lamp of 80 ampères, or 22,000 candle-power (20 times as strong as an ordinary lamp), are shut out by quartz prisms and by passing through cold water. The compressor, which consists of two rock crystal lenses with a current of running water between, renders the underlying tissues bloodless, and so facilitates penetration. The usual daily séance is an hour in duration.

In the red-light treatment of small-pox (and erysipelas) the ultraviolet rays are excluded by having red curtains over the windows, and, at night, using lanterns with red slides. In this way, Finsen claims that suppuration is prevented and mortality greatly lessened, though the duration of the disease is not shortened.

The electric light bath (up to 212° F.), originated by Kellogg, increases elimination more than a Turkish or Russian bath of the same duration. Perspiration is induced much more quickly and fully, because, though the skin is a poor conductor, it allows the passage of radiant energy in the form of light.

Fluorescent substances (quinin, esculin) are used internally in connection with the application of radium or X-rays, in order to produce greater medicinal effects. Good results have been obtained by painting superficial skin lesions with 5 per cent. eosin, and then exposing to sunlight.

Spectroscopy.—The spectroscope is an instrument for examining the various spectra of different substances. It consists essentially of one or more prisms, several convex lenses, and brass tubing to provide a proper focal distance. Flint glass has twice the refractive power of crown glass. By dovetailing one prism of the flint glass between two of the crown glass, the refraction of the latter is neutralized and the light passes through in straight lines, although dispersed into its component colors. The direct-vision spectroscope is all in one straight tube. The single-prism spectroscope consists of the collimator tube through which the light passes to the prism, and from this is refracted into the observing telescope. A third tube is sometimes attached so as to throw another beam of light on the prism, to be reflected through the telescope to the eye, for the purpose of comparison.

Experiment.—Let each student view the sky through the direct-vision spectroscope, and note the rainbow of colors crossed by dark lines (Fraunhofer's), which are designated by letters in the best instruments.

There are three kinds of spectra as studied with the spectroscope: continuous, bright line, and absorption. The first is produced by heating (without vaporization) a solid or liquid body in the flame near the slit of the spectroscope.

Experiment.—Show continuous spectrum with platinum wire. The first color to appear is red. Monochromatic light, of course, yields only the image of the color present in the flame.

When a solid or liquid is converted into vapor by increase of temperature, the series of colored bands is marked here and there by bright lines, the number and position of the lines indicating almost at a glance the element or elements present in any compound. As the chlorids of the metals volatilize more readily than do other metallic salts, it is customary to dip the wire into strong hydrochloric acid before taking up the substance to be tested.

Experiment.—Examine first the spectrum of a sodium salt; note the two bright-yellow lines, often appearing as one line (D line). Then examine and compare the spectra of salts of lithium, potassium, and strontium.

Li shows a brilliant red (to right of K line) and a fainter orange line distinct from the sodium line. Sr gives lines in the yellow, red and blue; Ba in green; Cs in blue; Rb in violet and dark red; Tl in green.

The spectroscopic method of analysis is not only very convenient in many cases, but is also exceedingly delicate, revealing, as it does, the presence of only $\frac{1}{200000000}$ grain of sodium.

When a substance in solution or in the gaseous state is interposed between the slit of the spectroscope and the source of light, we get absorption-spectra: that is to say, dark lines and bands where the same substances held in the flame would yield bright lines or bands. The interposed gas or liquid seems to absorb the corresponding rays of the same wave-length as the rays it emits. The formation of absorption-spectra is much employed in organic spectroscopy, particularly in testing for blood and its derivatives.

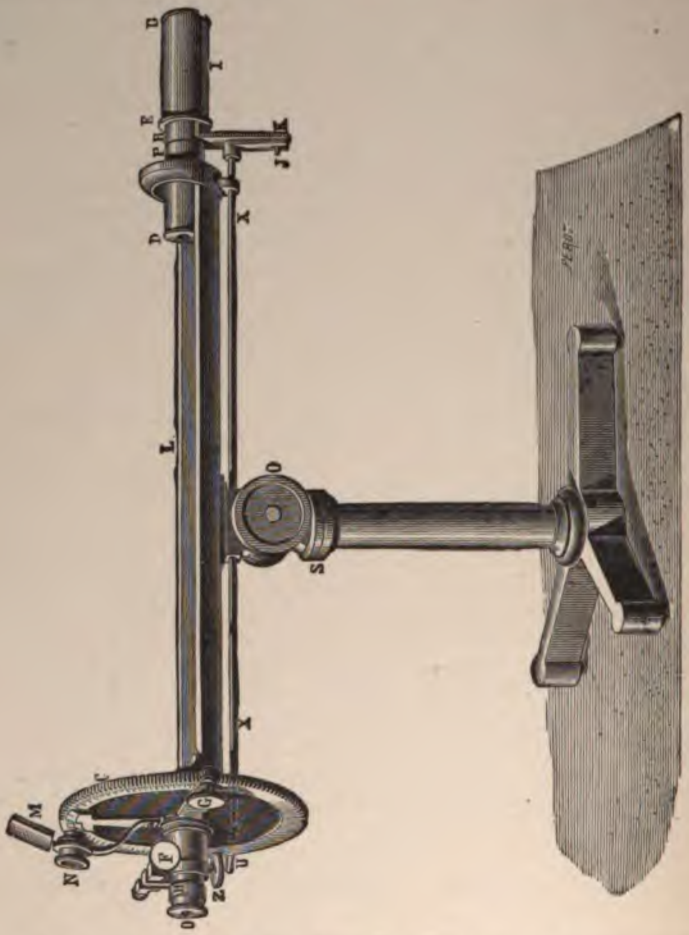


Fig. 14.—The Laurent Shadow Polarizing Saccharimeter.

Experiment.—Study and describe the absorption-spectrum of a 0.1-per-cent. solution of potassium permanganate, in a narrow test-tube held between the slit and the flame, in which a platinum wire is hung.

The dark lines of the solar spectrum are due to absorption by the luminous atmosphere of the sun of the corresponding elementary rays in the solid solar sphere. The visible solar spectrum represents only one-third of all the solar rays. The wave-lengths of the Fraunhofer lines range from 7604 tenth-meters ($10^{10} = 1$ meter) for A, to 5892 for D, and 3933 for H_2.

By comparison with the absorption-spectra of terrestrial elements, it has been found that nearly all of these exist in the sun, and in the same way the chemic composition of many stars has been determined. By means of this delicate instrument a number of rare elements have been discovered: cesium, rubidium, indium, gallium, thallium, and scandium. A most practical use of spectrum analysis is the detection of adulterants and impurities in chemic preparations. The spark spectrum is much more delicate and complete than is the arc spectrum. Spectra are influenced by pressure and temperature, and it has been shown that the same element can be caused to have different spectra.

Double Refraction.—Some substances, as Iceland spar, have the peculiar property of breaking up a ray of light into separate rays. This is called double refraction.

Experiment.—Make a pinhole in a card and place over it a piece of calcite. Note that two points of light are visible, and that when the spar is turned around one point revolves about the other.

The ray which is most refracted is called the ordinary ray; the other, the extraordinary, is the one which performs the circle about the first.

Polarization.—Light is propagated, as a rule, in all directions, perpendicularly to the line of radiation. When by the action of Iceland spar, selenite, or tourmalin the luminiferous waves are made to vibrate in a single plane, the light is said to be polarized, and the change is termed polarization.

The Nicol prism is a modified crystal of Iceland spar, the acute angles of which have been ground down to 68° and the crystal sawed diagonally in two from one obtuse angle to the other, and the two pieces rejoined with Canada balsam. The balsam is used to produce total reflection of the ordinary ray, which passes out at the side of the crystal. Tourmalin absorbs the ordinary ray, while the extraordinary one passes through.

Polarized light is not to be distinguished by the unaided eye. For this purpose we make use of two Nicol prisms, called, respectively, the polarizer and the analyzer. When the polarizer and analyzer are parallel as to their axes, light passes freely; but, when the analyzer is rotated so that its axis is at right angles to that of the polarizer, the ray is quenched. The polariscope is simply a combination of polarizer and analyzer; a polarimeter includes also a circular scale and a tube for holding solutions to be examined.

Many transparent bodies are optically active,—*i.e.*, rotate a ray of polarized light to the right or the left,—so that the analyzer must be moved a certain number of degrees farther either way in order to shut off the ray of light from the polarizer. Substances that rotate polarized light to the right are designated as dextrogyrous, and are indicated by the sign + ; those which exercise the opposite action are termed levogyrous, and are marked —.

For medical purposes the polarimeter (saccharimeter) is employed mainly in the quantitative estimation of sugars in solution. The specific rotatory power of any substance is the angle in degrees of rotation effected by a gram of the substance dissolved in 1 c.c. of water in a tube 1 dcm. long. The s.r.p. of cane-sugar (dextrose) is + 66.5; of levulose, — 94.4.

Since the effect of optically-active media varies with the length and strength of the different color-waves, it is necessary in quantitative testing to employ monochromatic light, usually yellow and obtained by burning sodium carbonate in the flame of a Bunsen burner. The letter D used in polarimetric formulas signifies the D line of the solar spectrum, which is the location of the sodium bright lines in the spectroscope; (a) D or [a] j means the specific rotation, using the yellow sodium light. $[A]^{20}$ D signifies also the temperature of the observation.

ELECTRICITY.

The word electricity is derived from the Greek name of amber, which was discovered by Thales, about 600 B.C., to possess electric properties: *i.e.*, to attract light bodies when rubbed. Twenty-two centuries later Gilbert, Queen Elizabeth's physician, found that many other substances were electric. In 1670 Boyle obtained the first artificial electric spark. Something over one hundred years ago Franklin, by means of a kite and string, demonstrated the identity of lightning and electricity. The past quarter of a century has seen such great advancement in the practical application of this agent that there can be no doubt we are entering an age of electricity with the passing of the age of steam.

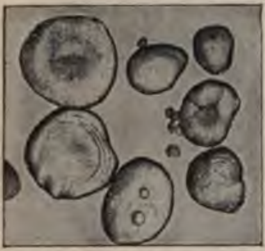
The exact nature of electricity is unknown. The latest investigations point to a return to the Franklinic theory of a current of electrons or negative corpuscles. In the electronic theory a body is positively electrified when it has lost electrons; negatively, when it has gained them.

According to the manner of production, electricity is designated as frictional or mechanic, inductive, chemic, thermal, and vital. Ideolectrics is a general name for substances which generate electricity by friction; anelectrics include non-electrics.

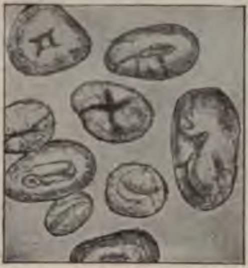
Frictional electricity is of two kinds: positive and negative (+ and —). That produced by rubbing glass with silk is termed vitreous, or positive; that by friction between flannel and resin is called negative, or resinous. The human body rubbed with wool becomes positively electrified; with silk, negatively. Negative electricity escapes very rapidly from incandescent metals or carbon.

Experiment.—Hang two pith balls from a support by a string of silk. Rub sealing-wax with flannel and a glass rod with silk, and

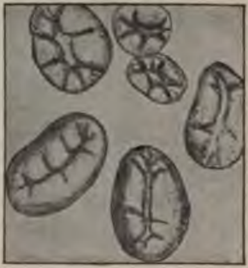
PLATE I.



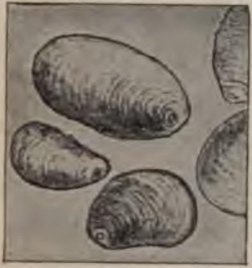
1, Barley.



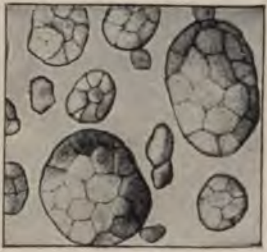
2, Pea.



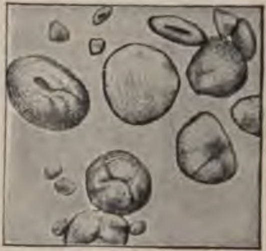
3, Beans.



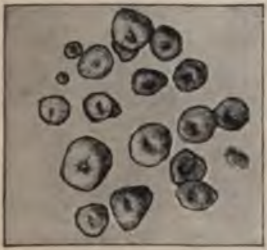
4, Potato.



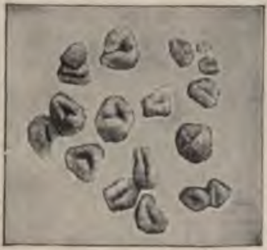
5, Oats.



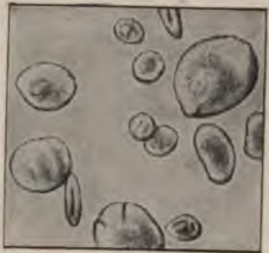
6, Wheat.



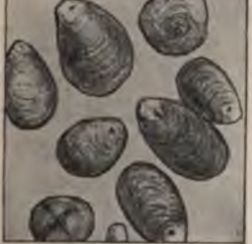
7, Maize.



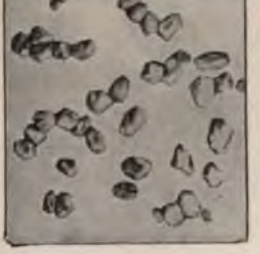
8, Rice.



9, Rye.



10, Arrowroot.



11, Buckwheat.

STARCHES. (*Leffmann and Beam's "Select Methods of Food Analysis."*)

charge each of the pith balls by holding the glass or the wax near them. Note that when charged alike the balls repel each other; when unlike, they attract.

The electroscope, usually employed for detecting the presence of electricity in a conductor, has two strips of gold leaf in place of the pith balls.

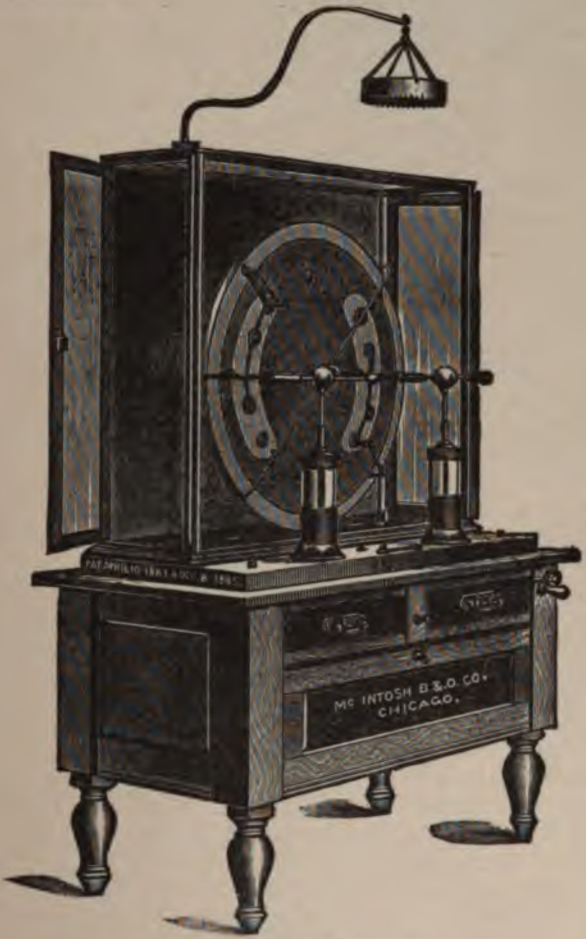


Fig. 15.—Electrostatic Machine.

Induction is the production of electricity in another body by the mere proximity of an electrified object. The pith balls are charged with electricity in this way. The charge is always of an opposite character to that of the inductor: thus the glass charges the pith ball negatively. When + and — electricities meet they are mutually neutralized or discharged, and the body affected is in electric equilibrium, or at rest.

The following rules of electric attraction and repulsion are important: 1. Unlike electricities attract, like electricities repel, each other. 2. The total electric attraction or repulsion between two substances equals the product of their electric power. 3. The strength of electric attraction or repulsion varies inversely as the square of the distance.

The electric machine is an apparatus for storing up electricity produced by friction between a circular glass plate and silk, leather, paper, or amalgam. Induction or influence machines are generally employed nowadays in place of the former machine. In these the plates are provided with small pieces of tinfoil or mica and are made to revolve near each other in opposite directions. Plate machines are affected by weather changes, as moisture conducts away the stored electricity. Anhydrous calcium chlorid should be kept in the case of static machines to take up the moisture.

Electricity is distributed only on the surface of bodies,—equally on a sphere, but mostly at the ends of other objects: the + electricity at one end, the — electricity at the other. Condensers, or accumulators, are designed to hold a large amount of electricity in a small space, and depend upon the principle that the capacity of an object to hold electricity is increased by the proximity of another insulated object oppositely charged. The Leyden jar is a familiar example. When thus stored up in waiting for liberation, electricity is termed static; when in motion, dynamic.

The passage of electricity from one point to another takes place by conduction and, to a less extent, by aerial convection. Metals, as a class, are good conductors, silver standing first, with copper a close second. Very poor conductors are called insulators, or dielectrics. Such are glass, rubber, dry wood, wax, resins, wool, dry paper, porcelain, air, and silk. Gas carbon is 2000 times as resistant as copper to an electric current. Water is a better conductor than air, the conducting power of which decreases with increase of temperature. The human body, particularly the skin, is a poor conductor of electricity, the average resistance being about 1000 ohms. Electricity escapes more readily from points than from smooth surfaces; hence the use of the combs on the condensers of some electric machines, and also the principle of the lightning rod, which is meant to bring together quietly and gradually the opposite electricities of earth and sky. A tube will carry twice as much electricity as a bar of the same size.

Atmospheric electricity is generally static, and is due to vegetation (gives off oxygen and carbon dioxid gases, charged positively), to evaporation, and to the friction of the wind on the ground. It is distributed mostly in open spaces, and is most abundant about noon. It is either positive or negative: the former always when the air is quite clear, and varies in potential from 75 volts negative to 300 volts positive. The electric conductivity of the atmosphere is said to be due to radioactive emanations from the earth's crust, and is greatly increased by the presence of radium or X-rays.

Lightning is the electric discharge in series, from the positively (usually) charged clouds to the earth, on which negative electricity has been induced. The flash itself depends on atmospheric resistance. Thunder is caused by the disassociation of water-vapor in the air.

The forms of lightning in order of frequency are sheet, linear, heat (too far away to hear thunder: more than fifteen miles), and globe. The course of lightning is generally zigzag, on account of the varying resistance to its passage through different atmospheric strata. The earth is the great common reservoir of electricity, and occasionally lightning ascends from the ground to the clouds when the latter are negatively charged.

The effects of lightning on human beings are those of artificial electricity, namely: burns, escape of blood from the vessels, shock, deafness, blindness, paralysis, and sudden death from hemorrhage into the medulla. Persons at some distance from the spot where a "lightning-stroke" occurs often suffer from what is styled the return shock. That is, on the approach of the electric force from the clouds the body becomes charged by induction with the opposite kind of electricity, which is suddenly lost when the terrestrial and atmospheric charges neutralize each other. Fulguration is a term applied to the effects of lightning: sideration, to the effects of electric currents.

Static electricity is used to some degree for medical purposes. It has one advantage over other kinds of electricity, and that is its greater tension or penetrating power or capacity of overcoming resistance; it can be administered through the clothing. Its effects are due chiefly to extremely high polarization of nerve and muscle (Massey). The spark is whitest (from incandescent oxygen) near the positive pole.

Galvanic, or voltaic, electricity is that form produced by chemic action. A galvanic cell consists of a chemic solution, usually an acid mixture, in which are placed two (or three) plates, the upper ends of which are connected by copper wires. The plates must differ in susceptibility to the chemic action of the fluid. The one that is more acted on is called the positive plate; the other, the negative. In medical electric apparatus zinc is usually employed for the + plates; gas carbon for the negative (Grenet cell). The wire attached to the + plate is termed the — rheophore, and its end the — pole (cathode) or electrode; that attached to the — plate is the + pole (anode) or electrode.

Experiment.—Construct a simple galvanic cell with a piece each of zinc and carbon in a dilute acid. Connect the plates with copper wires, and note that chemic action is more marked when the ends of the wires are made to touch each other.

The electricity generated by chemic action at the + plate seems to flow in a circle or current from the zinc to the carbon and thence over the wires to the zinc plate again. When the two wires are joined, the circuit is said to be closed; when separated, the circuit is open. Making and breaking the circuit is another way of expressing the same thing.

The two poles can be distinguished (1) by immersing them in a little water, when bubbles will be seen to collect on the cathode; or (2) by placing one on either side of a strip of unsized paper wet with a solution of potassium iodid, a brown stain appearing at the anode. Applied to the tongue, the current gives an acid taste at the + pole; a weaker, alkaline taste at the — pole.

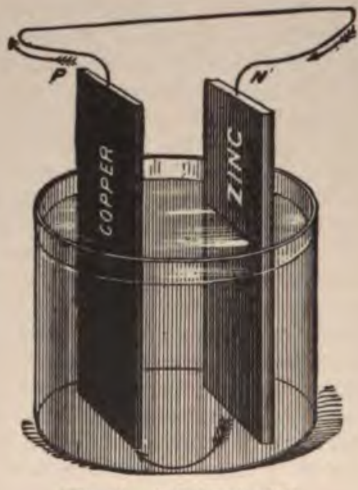


Fig. 16.—A Galvanic Cell.

A battery is simply a combination of galvanic cells. The arrangement of the cells in a galvanic battery varies with the particular use desired. For medical purposes the cells are connected in series, or tandem, *i.e.*, the carbon of one cell to the zinc plate of the next. They are linked here for intensity—to overcome high external resistance, namely: that of the skin. When the internal resistance—that of the battery-fluid—is comparatively great, the cells are linked for quantity, carbon to carbon and zinc to zinc, broadening the path of the current through the fluid. This arrangement is known as parallel, abreast, or in multiple arc.

The battery-fluid, or electropoion, most commonly used consists of 2 drams of bisulphate of mercury dissolved in a pint of water, to which is added 3 ounces of powdered dichromate of sodium and then slowly 3 fluidounces of commercial sulphuric acid. The office of the sodium salt is to unite with the hydrogen set free from the acid in the action of the latter on the zinc. When hydrogen is not taken up in this way bubbles of the gas soon form a coating on the carbon plate, interfering with the passage of the current.

The Daniell cell is a glass jar containing a saturated solution of copper sulphate, in which stands a copper cylinder, and within the latter a porous cup containing a strip of platinum in nitric acid and zinc in sulphuric acid. The Leclanché cell (carbon cylinder open circuit battery) has a zinc rod coupled with a compressed cylinder of carbon and manganese dioxid. The ammonium chlorid solution, also present, acts on the zinc (forming $ZnNH_4Cl_3$), while the hydrogen is oxidized and removed by the oxid of manganese. This battery polarizes rapidly, but is of use for short periods intermittently—depolarizing when left to itself. Its E.M.F. is about 1.5 volts; resistance, 0.7 ohm. The ordinary dry cell (1.5 volts, 0.54 ohm) is a zinc cell (internal plate surface) containing a pasty mixture of ammonium chlorid, zinc chlorid and plaster, and in the center a carbon plate surrounded by granulated carbon and manganese

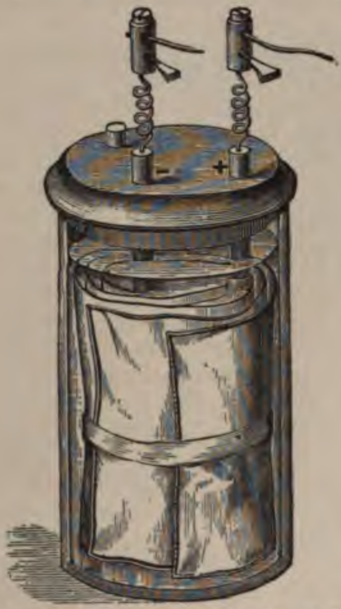


Fig. 17.—Faure's Modification of the Planté Storage Cell.

dioxid, with a porous septum separating them from the chlorids. Just enough water is added to moisten the granulated carbon, and the top is hermetically sealed.

In the storage, or secondary, battery plates of sheet-lead are immersed in dilute sulphuric acid, the dichromate being omitted. A current of electricity is passed through from the ordinary, or primary, battery. Hydrogen collects on one plate and oxygen on the other. The charge, or polarity, thus produced remains for several weeks. Connecting the plates yields a current of a strength about double that of a primary cell, and opposite in direction. Storage batteries are also made from red lead rolled up together with two perforated lead sheets, with flannel between, and immersed in dilute sulphuric acid. Metallic lead collects on the cathode and the peroxid of lead on the anode through chemic decomposition when the current is on. Edison's "charging machine" has cells of nickel oxid and iron oxid immersed in an alkaline fluid.

Flaws or impurities in the zinc plates of a galvanic battery lead to the formation of local currents that tend, of course, to weaken the main flow. To obviate this defect it is customary to coat the zinc with quicksilver, which forms a smooth amalgam, and thus prevents the local action mentioned. The bisulphate of mercury in the formula given above will keep the zinc plates well amalgamated. A rusty surface inpedes the passage of the current, and care should be taken not to let the acid fluid come into contact with the external parts of the battery.

The electric current is the result of a difference in potential (charge) of different bodies or parts of a body: much on the same principle as that "water seeks its level." The electromotive force (E.M.F.), or tension, is the total electric energy, or current ability, or pressure arising from a difference in potential. It is the result of a tendency to re-establish equilibrium, and has been compared to the force used with a pump in driving water through a pipe from a reservoir to a higher elevation.

The volt (element) is the unit of E.M.F. It is about equal to the power of a Daniell cell, or one-half the power of a Grenet or storage cell. The actual working strength of a current varies inversely as the length and directly as the square of the diameter of the conducting-wire. The unit of resistance is called the ohm, and is equal to the resistance, at f.p., of a column of mercury of uniform thickness 1 sq. mm., 106.3 cm. in length and weighing 14.45 gm.; or to that of a copper wire 250 feet long and $\frac{1}{20}$ inch in diameter. The resistance of the Atlantic cable is 700 ohms. For practical purposes coils of known resistance are employed for measuring ohmage. A megohm is 1,000,000 ohms; a microhm, $\frac{1}{1000000}$ ohm.

The unit of volume or quantity of actual current is called an ampère (weber), and is equal to a volt of E.M.F. passing through an ohm of resistance. One ampère of current deposits electrolytically 1.177 gm. copper per hour.

For medical purposes the ampère is divided into thousandths, —*i.e.*, milliampères,—of which from 1 to 100 or more may be administered, according to the special indications. The milliampèremeter is an instrument for measuring current strength in the medical application of electricity. It consists essentially of a magnetic needle, around which the conducting wire is made to pass. The degree of deflection of the needle thus occasioned (by induction) indicates the exact strength of the current. The Weston milliammeter depends on the mutual induction of coils. The E.M.F. of the static current is determined by the diameter of the revolving plates, and the volume by the number of plates (8 to 12). The silver voltameter consists of a rod of pure silver (anode) immersed in potassium cyanid solution in a platinum or silver dish (cathode), the silver being deposited on the cathode by electrolysis. One coulomb separates electrolytically per second 0.0104 mg. hydrogen or 1.1175 mg. silver.

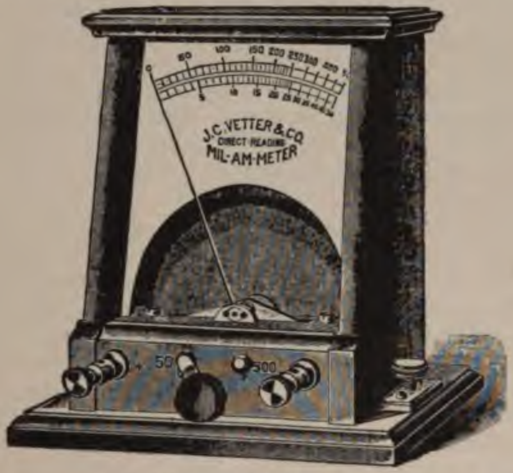


Fig. 18.—Horizontal Mil-am-meter.

The current is regulated, decreased, or increased, by the introduction of more or less of a poor conducting material, as graphite or water, or coils of German silver wire, known technically as a rheostat. The principle of the rheostat is like that of a sluice, which can be raised and lowered. When a current of electricity is passed in the reverse direction to a galvanic cell, chemic change is diminished, annulled or even reversed.

The resistance and its complement, the conductance, are inversely proportional to each other. Resistance is increased in metals (conductors of first order) and diminished in salt solutions (conductors of second order) by elevation of temperature. Resistivity is the specific resistance of a column of substance 1 m. long and 1 sq. mm. in cross section. That of silver being taken as 100, that of mercury equals 5953. Conductivity is the complementary term. Current density is the current in units of current strength per sq. cm. of cross section of conductor. The potential gradient (gradual diminution of potential difference in units of E.M.F. per cm. of conductor) is determined by dividing the current density by the conductivity.

Other units used in electric measurements are as follows: The coulomb, or unit of quantity, the force of a dyne at 1 cm., is an ampère-second: *i.e.*, a current of an ampère in one second of time. The farad of static electricity is equivalent to a coulomb-volt. The watt, or unit of total electric energy, represents the product of the voltage and ampèrage, and is equivalent to $\frac{1}{746}$ horse power. A volt through an ohm = ampère (rate) = coulomb (quantity in second) = joule (work done) = watt (rate at which work is done). An "electric horse power" = 1.34 kilowatt. The henry is the unit of induction in a circuit with one volt of E.M.F., while the inductive current varies one ampère per second.

The effects of the galvanic current are physic, chemic, and physiologic. Heat, light, sound, and mechanic motion may be produced by a sufficiently strong current. One of the most interesting of chemic effects is that of electrolysis, or decomposition of a substance (usually in solution) into its elements. Water, for instance, is broken up into hydrogen and oxygen. Only those liquids which are conductors can be decomposed electrolytically. The modern view is that solution of an electrolyte causes dissociation, and the galvanic current separates the already liberated ions at the respective electrodes.

When a salt in solution is electrolyzed the metal, or alkaline part, or cation, collects on the negative platinum pole; and the negative, or acid part, or anion, at the positive pole. This fact is made use of in gilding, electroplating, and electrotyping, in analysis and the extraction of metals.

In the two former processes the object to be coated is suspended from the — pole of a battery, while a piece of the metal desired is attached to the + pole, both being immersed in the plating fluid, usually a solution of the cyanid of the metal in question. When the current is set in operation the dissolved substance is decomposed, with deposition of the gold, silver, or nickel on the object attached to the pole. Articles to be plated should first be thoroughly cleansed with a hot solution of caustic potash or by pickling in a mineral acid, then given a thin film of mercury ("quicking") by washing in a solution of mercuric nitrate. Electrogilding is best done in hot solutions.

Electrotypes are made much as follows: An impression is made with the lines of type in melted wax, which is then coated over with powdered graphite. The mold is then suspended from the — pole in an acid bath of cupric sulphate, containing also a copper plate hanging from the + pole. The passage of the current acts in the same manner as for electroplating. The process of photogravure also depends on electrolysis and on the fact that potassium dichromate in a gelatin film is not soluble after being acted upon by light.

Experiment.—Decompose potassium iodid solution containing a little boiled starch by means of electrolysis. Note the blue color produced by the action of free iodin on the starch.

Experiment.—Make a "tin tree" by electrolysis, using a solution of stannous chlorid acidulated with hydrochloric acid. On which pole do the tin crystals collect?

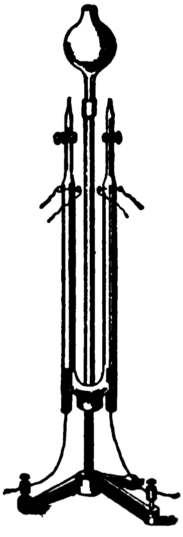


Fig. 19.—Electrolysis.

The galvanic, or constant current, as it is often called, is much used in medicine, especially to stimulate and exercise by contractions paralyzed muscles, in this way preventing atrophy until Nature restores the nervous connections. Electrotonus is the name applied to the increase of the normal nerve-current induced by the passage of a galvanic current along the nerve. Both the normal nerve-current and the electrotonic condition are shown by the galvanoscope or galvanometer (milliampère-meter). In electrotonus the excitability of the nerve in the neighborhood of the positive pole is decreased (anelectrotonus), whereas at the negative pole it is augmented (catelectrotonus). Hence, if an excitant action is desired the cathode is placed over the part; if a sedative, the anode is applied. The anode has a vasoconstricting, coagulating and hemostatic action; the cathode acts as a vasodilator. Acid substances diminish, alkaline agents increase the normal nerve-currents. The current is reversed by weakening ("negative variation") when nerves and muscles are stimulated and tetanized.

The electric reaction of the nerves (and the muscles they supply) originating at or below a spinal lesion is rapidly diminished and soon lost from degeneration due to trophic changes. In central, or brain, paralysis, on the other hand, the response of the nerves and muscles on the paralyzed side is not less marked than on the sound side. Normally the greatest effect is elicited on cathodic closing and anodic opening of the circuit, but in the degenerative condition just mentioned the opposite phenomena obtain: *i.e.*, the contractions are greatest on anodic closing and cathodic opening. Such an alteration is termed the reaction of degeneration and is accompanied by loss of faradic and increased voltaic irritability.

In employing the constant current for a stimulant effect on muscles and nerves it is customary to lessen resistance by using a rather large sponge electrode moistened with water or brine. The sponge is used dry when the stimulus is to be confined to the skin. The resistance is less in places where there are many sweat glands and diminishes with the action of the current. The galvanic current has no effect, except electrolysis, in the period between the make and the break. It should be turned on gradually to the required dosage; the *séance* may last from one to ten minutes, and then the current should be turned off slowly, thus avoiding annoying shock to the patient. Three hundred volts (alternating current) have caused death in man.

Another common medical use of galvanism is for its electrolytic effect in resolving tumors, strictures, etc. For this purpose a suitable metallic electrode attached to the — pole is employed. If a drying action is desired, as in the case of an unhealthy ulcer, the electrode should connect with the + pole, around which the negative, or acid, substances congregate. The action is most marked in morbid tissues of low vitality.

Experiment.—Attach an ordinary steel needle to each pole of the battery, and pass the current for ten minutes through a piece of meat. Note changes in needles and surrounding areas.

Epilation, or the permanent removal of hair, by electricity is an example of electrolysis, the needle used to pierce the hair-follicle being attached to the cathode. Cataphoresis, or the forcing of medicaments into the tissues by means of the constant current, is but seldom employed, having little, if any, advantage over the ordinary methods of administering medicines. Electrocauterization is of great service in the treatment of diseased mucous membranes. For cautery effects the storage or secondary battery is usually selected, on account of the greater intensity of its current; and the electrodes are of platinum, because of its resistance and infusibility.

Sinusoidal alternating currents are intermediate between constant and induction currents. They are produced by small alternating current dynamos with permanent magnets or electromagnets. They produce no chemic effects, and each wave moves in the opposite direction to the preceding one. The sinusoidal current has a smooth and gradual variation above and below the zero line.

By its frequency is meant the number of waves per second. Periods are double waves; two in opposite directions. It is typically adapted for muscle stimulation, and is not so painful as the ordinary induced current. Sinusoidal currents of considerable potency and a frequency of 100 to 200 per second give rise to serious and even fatal accidents, and are used for electrocutions. If the potential is increased and the frequency reaches several hundred millions or several billions, whatever the voltage the current becomes harmless. This strange fact is comparable with the fact that sound affects the organ of hearing and light that of sight only within certain limits of vibrations. A cycle of alternating current consists of a double wave. Street currents range from 40 to 150 cycles per second.

Frictional electricity travels at the rate of 288,000 miles per second; the long Hertzian waves, at the same rate as light. In practice the galvanic-current velocity depends largely on the length of the circuit and the character and area of the conductor. Nerve-currents move at the rate of only 35 to 100 meters per second. Frictional electricity is small in amount, but of high tension; current electricity is of low tension but greater quantity.

Thermo-electricity is generated by heat in conductors of relatively small caliber or in obstructed conductors. While this form of electricity may be produced in a single metal, it is customary to solder together one end of bars of two metals, heating the bars at their junction. The thermo-electric pile consists of 49 pairs of bismuth and antimony bars arranged in 7 rows. The thermo-electric current is feeble, though steady and convenient. Other piles are made of 70 or more pairs of iron and type-metal, or of iron and galena.

Vital electricity is possessed by plants as well as animals. The most striking example of animal electricity is the *Gymnotus,* or electric eel of South America, which is said to give shocks so strong as to stun horses and cattle. Its electric apparatus consists of a series of prismatic tubes filled with an albuminous liquid, arranged along the sides of the body and connected with a special lobe of the brain. The strength of a series of discharges of vital electricity gradually lessens from first to last. Animal electricity is mainly, if not wholly, of the static variety, usually positive.

MAGNETISM AND ELECTROMAGNETISM.

Magnetism is the property of attraction or repulsion of masses of like elements, exhibited especially by iron, nickel, and cobalt. It is a molecular force related to electricity. Each molecule is thought to be traversed by a closed electric circuit, and these currents become parallel when the iron is magnetized. The natural magnet, or lodestone, is an oxid of iron, which was first found in Magnesia, Asia Minor; hence the name of magnet.

Artificial magnets are made by rubbing with the lodestone or with other artificial magnets, or by induction from the electric current through a coil of wire. Temporary magnets, like that of the faradic battery, are composed of soft iron; permanent magnets retain the power of attraction for a long time, and are made of tempered steel or chilled cast iron.

Artificial magnets are of two forms: the bar and the horseshoe. The latter is generally employed. When not in use its armature, or keeper, should always be applied to prevent the escape of magnetism. Compound magnets are composed of thin sheets of steel screwed together; they are stronger than simple ones. The property of magnetism is lost at a red heat.

Experiment.—Show the action of a bar magnet on iron filings placed on the other side of a sheet of paper and of a piece of glass, proving that magnetism does not require the presence of air. Sift the filings on the paper and show how the lines of magnetic force radiate in all directions.

The two ends of a magnet are called its poles. No matter how small the magnet or into how many pieces it may be broken, each fragment has still two poles. When a magnet is freely suspended, one end, or pole, always points toward the north; the other, to the south. A needle magnet balanced over a circular chart constitutes the mariner's compass. An astatic needle consists of two parallel magnets on a common axis, with unlike poles suprajacent. It is not affected by the earth's magnetism.

Experiment.—With a bar magnet and a compass show how like poles repel and unlike attract.

The earth itself is a great magnet, its magnetism being due probably to electric currents flowing from east to west and generated by the sun's rays (sun-spots, northern lights). The magnetic poles of the earth do not correspond with the geographic poles. The north magnetic pole is in King William Land in 70° north latitude; the south pole in Victoria Land, 75½° south latitude. The longitude of these poles shifts from east to west and back again, the oscillation requiring centuries for its completion. At present the north magnetic pole is moving westward at the rate of 1° in twelve years. From these facts it is evident that the north pole of the compass points directly north only in the meridian which passes through the north magnetic pole. This meridian is known as the line of no variation. The "dipping" of the needle from the horizontal increases as we approach the magnetic pole, where it would stand vertical were it not counterpoised by a weight at the opposite pole.

The dual nature of magnetism is designated by the term polarity. Substances, like iron, that are attracted by the magnet and arrange themselves axially between its poles, are called paramagnetic. Those which are repelled and take an equatorial position between the poles are termed diamagnetic. Bismuth is the foremost example of this class. All substances in the form of heated gas are diamagnetic.

Besides the compass, the chief applications of permanent magnets are in removing pieces of iron or steel from the eye, in separating magnetite from sand and crushed rock, and in freeing malt and grain from pieces of scrap-iron. Soft magnets are employed very extensively in faradic batteries and electric dynamos. Literally, animal magnetism does not exist.

ELECTROMAGNETISM, OR ELECTRODYNAMICS.

When a bar magnet is placed within a coil of wire (solenoid), it sets up a current of electricity in the coil, and when the magnet is removed there is a current in the opposite direction to the first. Conversely, when a piece of soft iron is placed within a coil through which a current of electricity is passing, the iron becomes magnetic. When one coil is placed within or without another through which a current is passing, a secondary or induced current is produced in the former: in the opposite direction at the make of the primary or battery current, in the same direction at the break. In practice the primary helix, or coil, is made short and thick, so as to offer as little resistance as possible to the electric flow. The secondary coil, on the other hand, should consist of a long, thin wire, since, the longer (50 miles or more in powerful instruments), and thinner it is, the greater the induction. Both coils, of course, should be carefully insulated.

Experiment.—Show magnetic induction with iron tacks and magnets; how one tack attached to the magnet can be made to pick up another.

The Ruhmkorff induction-coil consists essentially of a galvanic battery with its connecting wires, a secondary helix, a soft magnet, a spring interrupter, and a condenser. The best coils give a spark, at the break, several feet in length. The faradic battery is the same as a Ruhmkorff coil minus the condenser. The draw-tube in the battery is placed between the primary and the secondary coils, and when drawn out increases the current by removing obstruction to induction.

The two faradic currents (primary and secondary) are also known as interrupted currents. The secondary, or induced, current, is stronger than the primary, or battery, current. Either current is much more intense at the break than at the make of the circuit, since at the break the extra current set up by induction between adjacent turns of the same coil runs in the same direction as the principal current, while at the make it goes against the main current and reduces its force. As a nerve-stimulant and muscle-tonic the interrupted current is preferred in most instances to the constant current. Galvanism (interrupted) has a deeper effect than faradism, and hence is employed in the treatment of internal organs and the stimulation of paralyzed muscles that do not react to the faradic flow. The high frequency, or high potential, current is the static induced current. The direct incandescent current (Edison) of 110 volts has the same effect as the galvanic, but has about one-third as much ampèrage, hence is less irritating.

The passage of electricity from a Ruhmkorff coil through vacuum apparatus, such as Crookes's tubes, gives rise to a brilliant display of phosphorescent light (cathode rays, electrons), of a greenish hue (on account of soda in glass), which sets up invisible discontinuous ether pulses on the outside of the tube, termed the X-rays. The cathode rays passed through an aluminum window are known as Lenard's rays.

The X-rays are peculiar in that they penetrate many objects opaque to ordinary light, such as wood, paper, and flesh. On the other hand, they do not pass through glass. It is easy to comprehend how they may be made to form a shadow, or silhouette, of bodies opaque to themselves on a sensitized plate, which may be developed as any other photographic negative (skiagram). The fluoroscope does away with the necessity of photographic methods in connection with the X-rays. It consists, in the main, of a sheet of pasteboard coated with some fluorescent material (platino-barium cyanid or tungstate of calcium), which reveals directly to the observer's eyes the shadow of the skeleton or of foreign bodies imbedded in the flesh. Fluoroscopy is, however, not nearly so delicate and certain as skiagraphy. X-rays and radium convert air and other gases into conductors of electricity, so that they discharge an electroscope when it is brought near.

High-vacuum or hard tubes have one-millionth per cent. vacuum. The rays of these tubes have small volume, but are more penetrating than from soft tubes. Vacua tend to become greater by use of the tubes. This is regulated by heating a sealed-in platinum wire containing occluded hydrogen, or is self-regulated by the generation of heat in a small auxiliary tube of low vacuum. X-ray burns are due to the greater number of rays in low-vacuum tubes; they are prevented by lead foil. X-rays are of great use in surgical (fractures, exostoses, foreign bodies) and dental (non-erupted teeth, abnormal roots, necrosis, abscesses) diagnosis, and have proved of value in treating skin diseases and superficial tumors. Morton gives fluorescein internally in connection with the use of X-rays, developing light in the interior of the body: 20 drops of a solution of fluorescein (1 to 30 of water), X-ray exposure 40 minutes later. Bismuth salts are often mixed with bread and milk or other foods to show the shape and position of some body cavity.

The electric dynamo is the basis of nearly all the practical industrial applications of electricity. It consists of a revolving electromagnet, or armature (consisting of a core of soft-iron wires, around which are wound coils of insulated copper wire, each connected with a knee-plate, from which the electricity passes off on metallic brushes, which run in opposite directions, since the polarity of the cores is reversed with each semirevolution); and a fixed, or field, magnet of soft iron. Traces of magnetism in the latter induce slight currents in the armature, and, by reaction between the two, currents of great strength are soon produced. These alternating currents may be turned in one direction by a simple contrivance called a pole-changer, or commutator. The currents thus produced pass over conducting-wires to be transformed as desired into heat, light, sound, and mechanic motion. The dynamo is run by steam or water-power. The Edison system has the direct current; the Westinghouse, alternating. Current controllers are made of graphite. Alternating currents are much more dangerous than continuous ones of the same strength and tension. The electric motor is, practically speaking, the same as the dynamo, in which the action is reversed, electric currents converting iron into electromagnets, which attract, then repel, the armature, setting it into rapid rotation. The movement of the armature is easily transmitted to the wheels of cars and machinery. "Fusible wires" of alloys that melt at a low temperature are often introduced into buildings to prevent fires from excessive currents of electricity.

Electric lighting depends on the resistance to the passage of electricity through a poor conductor or one of small caliber. The incandescent lamps are exhausted of air and contain a filament of carbon (bamboo carbonized at high temperatures in closed nickel moulds), which is brought to a white heat by a current of 50 to 120 volts. About one-half ampère of circuit is passed through an ordinary 16-candle power incandescent bulb.

The arc light is produced by the resistance of the air to the current (1000-3000 volts), passing between two adjacent electrodes. As most metals melt quickly in this terrific heat, the nearly infusible gas-carbon is employed for the electrodes, the sticks being kept at the proper distance, as the + pole wastes away, by an automatic feeding arrangement. Electric arc light is most like sunlight of any artificial product, and is also most hygienic. It is quite rich in actinic rays. Arc light gives 10 per cent. luminosity; incandescent, 5 per cent. The bow shape of the arc light is due to the magnetic action of the earth's lines of force on the current. The violet hub of the arc light is due to incandescent carbon vapor; the odor, to minute quantities of hydrocyanic acid. A frequency of about 60 cycles, or 120 reversals per second, is the best for lighting purposes. High frequencies cause a disagreeable humming. In the mercury lamp a constant electric current passes through a vacuum tube containing vapor of mercury. It gives a brilliant light almost devoid of red rays, but very rich in photographic frequencies.

The Nernst lamp contains a rod of zirconia acted on by the electric current. As there is no surrounding glass bulb, there is no loss of the chemic frequencies.

Electric heating, like electric lighting, depends on the resistance of poor conductors. This method is employed in small stoves, dental vulcanizers, and for heating cars and buildings. Electric furnaces (in which a core of coke or a graphite crucible and other forms of carbon are employed, along with concave pieces of lime) yield a very intense heat, which is used for fusing metals and for reduction purposes, as in the extraction of aluminum. Welding of the common metals is done now very extensively by electricity.

The electric current has many applications in apparatuses of speech and sound, as exemplified by the telephone, the microphone, the telegraph, the telautograph, and electric bells, clocks, and fire-alarms. In each of these we have a combination of electricity and magnetism. In the telephone, for instance, the vibrations of the thin diaphragm at the bottom of the speaking-tube set in motion by the speaker's voice react on the bar magnet behind, and this, in turn, induces variable currents in the surrounding coil of wire. These currents traverse the wire to the connected instrument at a distance, where the series of changes is reversed: *i.e.*, the magnet is affected by the current in the coil of wire, and the metallic disk of the receiver is magnetized and drawn nearer and released accordingly. For practical use each instrument contains a Leclanché cell (ammonium chlorid), or a dry cell, furnishing a constant current which the action of the vibrating disk on the magnet merely modifies. For long-distance conversations, as between different cities, powerful induction-coils are employed to furnish the current. The improved transmitter of Edison has in place of the magnet a button, held in loose contact by a spring with a platinum point at the back of the diaphragm, vibrations of which, by altering the contact between the point and the button, produce corresponding fluctuations in the current. Phototelephony is based upon the sensitiveness of an arc light to sound, and on the property of selenium of varying its electric resistance with the slightest variations of a ray of light falling upon it. A searchlight projector at the transmitting end and a selenium cell in a telephone circuit at the receiving end are the essential features in the apparatus.

In the telegraph (Morse, 1837) pressing the key at one office closes the circuit. When the finger is removed a spring pulls the key up. In the receiving office when the circuit is closed the key here is magnetized and drawn down upon the sounder; when the circuit is broken it springs up again, and thus the succession of clicks, or dots and dashes as shown on paper, is repeated by the instrument receiving the message. The earth itself is the best conductor of electricity, so that one line of wire is made to suffice for telegraphic communication, the wire being grounded at either terminus. In transmitting messages long distances the strength of the current is diminished so much that it is unable to move the sounder audibly. This difficulty is overcome by means of repeaters or relays, electro-magnets wound with long, thin wire, used to close the circuit of the local battery. Wireless telegraphy (Marconi) depends on the Hertzian waves of ether, or high-potential electricity. The apparatus consists of a vertical insulated wire; a transmitter, including a Ruhmkorff coil and two sparking rods with a brass ball; and, last, a receiver composed of two silver plugs in a glass tube, along with a mixture of nickel and silver filings. The resistance of the filings in the tube, or coherer, prevents the action of the relay until diminished by the passage of Hertzian waves, set in motion by the distant transmitter, when the local battery is closed and the message taken by means of the Morse printing instrument. In the Orling-Armstrong system electric impulses are sent through earth instead of air.

Electric bells, clocks, and fire-alarms act by the induction of a closed circuit on a soft magnet, which, in turn, sets in motion wheels, hands, or striking-springs.

The so-called electric belts, brushes, clothing, etc., are utterly useless and worthless. Obviously, even theoretically, they can return to the body only the electricity they have derived from it by simple friction or by a slight chemic action with the acid perspiration.

CRYSTALLOGRAPHY.

Most inorganic and many organic substances when assuming the solid state from fusion, solution, or sublimation tend to take on a symmetric geometric, or crystalline, form. The liquid and gaseous states aid crystallization by allowing the molecules to arrange themselves in order around the axes or lines of growth, *i.e.,* certain imaginary lines in which cohesive force is greatest. Crystals by fusion are said to be formed in the dry way; when from solution, in the moist way. The largest and most perfect crystals are those produced by Nature in the gradual evaporation of aqueous solutions of mineral salts. The process of crystallization can be hastened by immersing in the liquid strings, chips, and other foreign objects to serve as nuclei of growth. Rock-candy and milk-sugar are prepared in this manner.

Experiment.—Make a saturated solution of alum, in boiling water, and hang in it a piece of twine. When the liquid has cooled the excess of substance above its solvent power at the lower temperature will be found as crystals on the cord. The formation of the beautiful frost patterns on the windows in winter is another illustration of the same facts.

The forms of crystalline matter are quite numerous, yet they can be classified in six simple systems, namely: the monometric, dimetric, trimetric, monoclinic, triclinic, and hexagonal.

The monometric (regular, isometric) system has three axes which are equal in length and at right angles to each other. The primary type of this system is the cube, exemplified by iron pyrites. The regular octahedron (magnetite, diamond) and regular pyramid, or tetrahedron (fluorspar, tetrahedrite) are derived from the cube by truncation of its solid angles.

The dimetric, or tetragonal, system has also three axes at right angles to each other, but one of them is shorter than the other two. The two types of this system are the square pyramid, or acute octahedron (octahedrite), and the square prism or column (wernerite).

In the trimetric, or orthorhombic, system the three axes are perpendicular to each other, but are all of unequal length. The varieties are the rhombic and rectangular prisms and pyramids. Examples of substances belonging to this system are sulphur (rhombic octahedron), topaz (right rhombic prism), and andalusite (right rectangular prism).

The monoclinic, or oblique, system has three unequal axes, like the trimetric system, from which it differs by the vertic axis being set obliquely to the other two, instead of perpendicularly. The oblique pyramid (feldspar) and prism (orthoclase, rectangular; titanite, rhombic) are the subdivisions.

The triclinic, or doubly oblique, system has three axes no two of which are at right angles to each other. The doubly oblique pyramid (copper sulphate), doubly oblique prism (chalcanthite), and doubly oblique octahedron (axinite) illustrate this system.

The hexagonal, or rhombohedral, system has four axes, three of which are in the same plane at angles of 60° with each other; the fourth is perpendicular to the other three. The hexagonal prism (apatite) is the primary form. From it the hexagonal pyramid (quartz) is obtained by truncation of the angles of one end; the rhombohedron, or scalenohedron (calcite), by truncation of the alternate angles of either end.

When two substances crystallize in the same form they are said to be isomorphous. Potassium iodid and sodium chlorid, for instance, both crystallize as cubes. Isomorphous compounds frequently contain the same number of atoms.

Two isomorphic substances in the same solution crystallize together, the crystals formed containing particles of both compounds. Thus ordinary alum in solution with chrome alum gives beautiful colored octahedra. A substance which crystallizes in two or more systems is termed dimorphous or polymorphous. Sulphur is dimorphous (rhombic octahedron and monoclinic prisms). Non-crystalline substances are called amorphous: that is, without definite form. An allotropic element is one that exists in two or more crystalline or amorphous states, each with different physic properties. Carbon, for example, is met with as charcoal, plumbago, and diamond.

A characteristic of many crystalline rocks is that of cleavage, which means the property of splitting readily in one direction into natural layers. Mica furnishes a good example of this peculiarity. Crystals transmit heat, light and electricity differently in different directions.

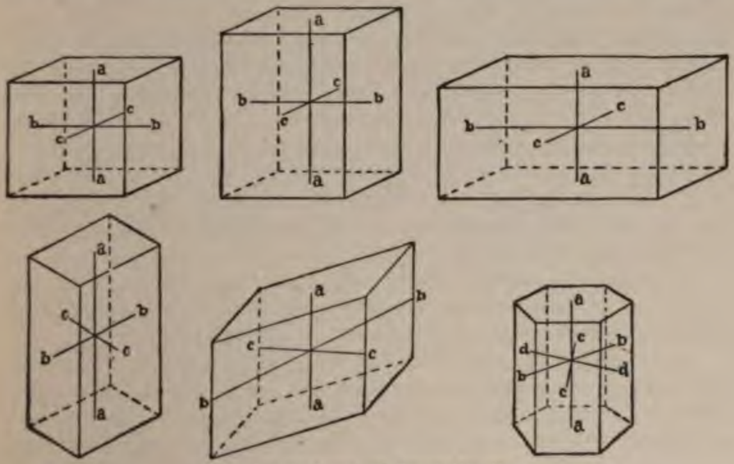


Fig. 20.—Systems of Crystallization.

The greater number of crystalline substances (crystallohydrates) are combined chemically with water, termed the water of crystallization; and to this the various colors of most crystals are due. The combination may be molecule for molecule,—that is, one of water to one of the solid substance; oftener, however, the water molecules much exceed in number those of the mineral matter. Alum, for example, has 24 molecules of water to 1 of the salt proper. A few compounds, as silver nitrate, crystallize without any water in their composition; hence are called anhydrous. Some substances take up more or fewer molecules of water of crystallization according as the process is conducted at a lower or higher temperature; the resulting crystals in such an event often differ from each other in size and shape. Sodium carbonate crystallizes at ordinary temperatures with 10 molecules of water in oblique rhombic prisms; at higher temperatures with 8 or 5 of water; from boiling solutions as rectangular plates with 1 of water. Crystals of cobalt chlorid dissolved in absolute alcohol give a blue solution (1 H_2O); in water, a red solution (6 H_2O). The chemic union between the water of crystallization and the remainder of the crystal is a very weak one, and is broken up in most instances by heating the crystals to the b.p. of water.

Experiment.—Heat a crystal of copper sulphate carefully in a porcelain dish, and note the disappearance of color along with the water of crystallization. Continue the heating until a dry white powder is left and allow to cool. Then place the powder in the palm and add a little cold water. The blue color is restored, and considerable heat is produced (chemic action). Copper sulphate loses ⅘ of its water at 100°; the remainder at 240°.

Anhydrous salts capable of combining with water absorb aqueous vapor from the air (deliquescence), since the tension of aqueous vapor in crystallohydrates is less than in water itself, thus acting like a cold body on steam. Dehydrating substances remove admixed water (including water of crystallization) from other bodies. Dehydrolyzing agents (zinc chlorid, sulphuric acid) remove hydrogen and oxygen in the proportion to form water, which they then take up. Heat often has a dehydrolyzing as well as a dehydrating action.

Some crystalline drugs (sodium compounds) lose their water of crystallization gradually on simple exposure to dry air. These bodies are designated as efflorescent.

On the difference in solubility, and hence the temperature at which crystalline solidification takes place, depends the separation of substances by fractional crystallization, the least soluble substance crystallizing first out of the cooling or concentrating solution. In this way common salt is prepared from sea-water, the more soluble salts remaining in solution in the mother liquor, or bittern. The order of deposition of salts from a mixed solution depends not only on their relative solubility, but on the concentration of each salt.

Another use of crystallization is in purifying medicines, as foreign matters are dissociated to a large degree during the formation of crystals. Hence, ice is purer than the water from which it was formed. In chemic microscopy the ability to recognize the crystalline forms characteristic of various compounds is of the greatest practical importance.

OSMOSIS AND DIALYSIS.

Osmosis signifies the stream of water molecules passing through a membrane; dialysis, the passage of the molecules of a dissolved substance. When pure water and an aqueous solution of a salt are separated by a semipermeable membrane (one which allows water, but not the salt, to pass, such as finely-divided potassium ferrocyanid deposited in fine-grained porcelain), the osmotic pressure is greater toward the side of the salt solution, the dissolved molecules of the salt seeming in a manner to screen the membrane from contact with a certain number of water molecules. The osmotic pressure varies directly with the concentration of the solution (molecules or ions), and the highest hydrostatic pressure thus exerted has been proved equal to that caused by as many molecules of gas as in that of the crystalloid in solution, if confined in the same space at the same temperature. Solutions of substances containing the same number of particles (molecules and ions), in a given volume exert the same osmotic pressure, and are said to be isohydric. With a given solution the osmotic pressure is proportional to the absolute temperature. The pressure decreases and the movement of liquid becomes slower as the process goes on. In filtration the concentration of the filtrate is in direct proportion to the pressure in crystalloid solutions—inverse proportion with colloid solutions.

All the body cells are permeable to water, but each kind differs from others regarding the permeation of solids, which, if they cannot penetrate the cell, exert osmotic pressure on it, and such changes continually taking place cause cellular equilibrium to vary constantly. If a membrane contains fatty particles (lipoids) the surface tension of the osmosing fluid is much diminished, and the speed of osmosis increased. Medicinal substances which osmose (are absorbed) rapidly are soluble in lipoids and diminish surface tension. The osmotic pressure of the blood reaches its maximum shortly after the midday meal. The clay pastes, frequently applied to the skin, do not exert as much osmotic pressure as does a simple cotton jacket. Bacteria show positive chemotaxis in sufficiently dilute saline solutions, but are repelled (negative chemotaxis) by strong solutions.

Osmosis is essentially a manifestation of capillary or surface attraction. The tonoplast, or elastic membrane, lining plant cells, is a semipermeable membrane, allowing water, but not its contents, to pass. Only by maintaining the normal tension or turgor in its cells can the plant thrive and grow. The juices of rootlets in a saturated soil draw water out of the soil; if unsaturated, the soil draws water from the plant. Probably the most important factor in plant production is the capacity of a soil to deliver water; hence the value of cultivation and irrigation.

The functions of the red blood-cells, and indeed of all the body tissues, are vitally modified by osmotic pressure. Loeb has shown that the act of fertilization in some lower animals can be, in part, replaced by a definite increase in osmotic pressure in the liquid containing the eggs (parthenogenesis).

Most inorganic substances when in solution break up, or dissociate (Arrhenius), into two or more parts (charged with opposite electricity) known as ions (freely moving electrons of different voltages), and the greater the dilution, the more complete the dissociation (quite complete at about 1/1000 normal). Such substances are called electrolytes. Thus, sodium chlorid dissolved in water dissociates more or less into the positively charged cation sodium and the negatively charged anion chlorin. Sugar, on the other hand, though soluble and crystalloid, is a non-electrolyte. Normal cane-sugar solution on one side of a semipermeable membrane will raise water 30 feet in a capillary tube. The electric conductivity of solutions is a measure of the degree of dissociation. The faster an ion moves, the more powerful it is; the heavier and slower, the less powerful. The toxic effects of ions vary inversely as their solution tensions.

Ions can pass through membrane only when accompanied or exchanging sides with ions of an opposite sign. Certain animal membranes are permeable in but one direction. Thus an egg membrane allows water to pass inward but not outward, and the stomach wall appears to be permeable for water only from the outside into the stomach. In osmotic pressure ions are of equal value to molecules; hence, the smaller the molecule and the more the dissociation, the greater the pressure. Water, grain alcohol and acetone ionize most electrolytes; glycerin and acetic acid are indifferent; chloroform, ether and benzin ionize little, if any, the substances they dissolve.

The osmotic pressure of non-electrolytes in solution is readily calculated by comparing gram-molecular solutions (containing the molecular weight of the substance in grams per liter) with the pressure required to compress the gram-molecule of hydrogen (2) to a liter. Thus, a gram-molecular solution of cane-sugar contains 342 gm. per liter, and it contains as many molecules as 2 gm. of hydrogen. Now, 1 gm. of hydrogen at the pressure of 1 atmosphere (760 mm. of mercury) occupies a volume of 11.16 liters; hence 2 gm. occupy twice this volume, or 22.32 liters. To compress the latter volume to a liter requires a pressure of 22.32 atmospheres. A gram-molecular solution of cane-sugar (or any other non-electrolyte) would therefore exert an osmotic pressure of 22.32 atmospheres; and equimolecular solutions of all substances are isosmotic. Gram-molecule is often abbreviated to mol or mole. Equimolecular solutions have the same f.p. The b.p. of water is raised 0.52° by every gram-molecule dissolved in a liter. Albumin has a molecular weight of about 13,000, a molar concentration (moles per liter) of 0.008, an osmotic pressure of only 0.17 atmosphere.

The relation of pressure (P) in atmospheres to concentration (C), or number of gram-molecules per liter of solution, and absolute temperature (T), can be expressed as $P = 0.86\ CT$. Depression of the freezing point by 1° C. indicates an osmotic pressure of 9437 mm. of mercury, and a solution which exhibits an osmotic pressure of one atmosphere at 0° freezes at — 0.084°.

In the case of electrolytes a very convenient method of determining osmotic pressure is by means of the f.p. As already stated, this is lowered by the presence of salts in solution, and the lowering has been proved to be proportional to the number of molecules and ions in a given volume: a fact which holds good as well with osmotic pressure. The amount of depression in centigrade degrees and fractions below the f.p. of pure water is ascertained by means of a delicate differential thermometer, and is usually expressed by the symbol △. A gram-molecular solution of any non-electrolyte lowers the f.p. 1.85° C.; hence the osmotic pressure of a given solution can be expressed directly by dividing the constant 1.85 into the △ of latter. Thus, the △ of blood-serum is 0.56; this divided by 1.85 gives 0.3; and 0.3 of 22.32 = 6.696 atmospheres, the equivalent of the osmotic pressure of blood-serum.

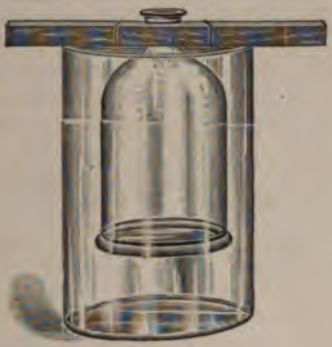


Fig. 21.—Dialyzer.

In case of drowning the blood from the left heart shows a much smaller △ than that of the right. The △ of normal urine is 1.2 to 2.3; of cows' milk, 0.55-0.56. The isotonic coefficient *(i)*, or van't Hoff's factor, is the number (always greater than unity) by which the normal value of the osmotic pressure must be multiplied to determine the actual osmotic pressure of an acid, basic or saline solution. This factor is obtained by dividing the actual △ of a molar solution by 1.85.

From the physic standpoint an isotonic or isosmotic solution is one having an osmotic pressure equal to that of blood-serum. A hypertonic solution exerts a higher, and a hypotonic solution a lower, pressure than does serum. The term anisotonic includes hypo- and hyperisotonic.

If a salt permeates the blood-cells, the △ plays no part concerning the effects of its solution on the cells. Permeating salts, like urea or ammonium chlorid, cause the cells to swell up and lose their hemoglobin, as pure water would do. Alcohols and free acids and alkalies also permeate the blood-corpuscles; sugars do not. Sodium, but not chlorin, ions can pass into the cells. Pure water is taken up more readily than isotonic salt solution from the bowel, and physiologic saline solution is often made a little under isotonic strength (0.25 calcium chlorid, 0.1 potassium chlorid, 9 sodium chlorid, sterile water q. s. ad 1000), so that when injected by hypodermoclysis it will diffuse as freely as blood-serum.

The great difference in the rate of membranous diffusion of crystalloids and colloids makes the separation of one class from the other an easy matter. The dialyzer, an instrument for this purpose, consists of a round glass vessel open at the upper and narrower end, and closed at the bottom with a piece of parchment paper. The mixed solution is placed in the dialyzer, and the whole immersed to a slight depth in distilled water for 12 or 24 hours. At the end of this time the crystalloid substance will be found, for the most part, in the water exterior to the vessel, while the colloid material still remains within. A few amorphous substances (peptones) are crystalloid.

The process of dialysis is of greatest service in toxicology, in the separation of crystalloid poisons from food and other stomach contents. It is also used to some extent in the preparation of drugs.

Experiment.—Place a copper sulphate solution and some white of egg into a dialyzer, and let stand until the next day. The blue color of the copper salt now shows without as well as within the vessel, but the albumin has not diffused: the liquid within the vessel coagulates on boiling, while that without does so hardly at all.

SOUND.

Sound consists in vibrations of the air or of sonorous (elastic) substances perceptible to the sense of hearing. The science of sounds is known as acoustics.

Experiment.—Fit a large test-tube with a tight cork fitted with a short, pointed glass tube. Place a few granules of zinc in the bottom of the test tube, and cover them with an inch or two of dilute sulphuric acid. The gas hydrogen is evolved. After a few minutes, when all the contained air has escaped, light the gas, and hold the flame in the mouth of a glass cylinder about an inch wide. On adjusting the flame to the right point in the tube, a loud tone is produced by the vibrations of heated air in the cylinder. Sounds can also be produced by an intermittent beam of sunlight playing on colored worsted or lampblack in a glass tube.

Experiment.—Place a watch on cotton-wool, under the air pump and create a vacuum. The ticking becomes fainter, and is finally imperceptible.

Sound is transmitted by spheric waves or undulations, at the rate in air of about ⅕ mile per second (1125 feet at 60° F.); in water 4 times as fast; in iron 16 times as fast. In gases the velocity of sound varies as the square root of elasticity and inversely as the square root of density. Water is much more elastic than air.

A wave-length is the distance between any point on a wave and a similar point on the wave before or behind it. The amplitude of vibration is the greatest distance traversed by a particle in either direction from a median position: that is, a wave-height. Musical notes are produced by repeated, rapid, regular vibrations; noise by a single short sound or a confused and irregular mixture of sounds. Friction is always rhythmic, as shown in the singing sound of the speeding rifle ball, and the "waterfall tones" of the wind in the tree tops.

Loudness, or intensity, varies inversely as the square of the distance and directly with the square of the amplitude of the vibrations; also with the density of the medium and atmospheric motion. It is increased by reflection from a neighboring sonorous body, such as a sounding-board, or from the walls of a room (resonance), and is maintained for long distances in straight, cylindric tubes (speaking tubes). Echoes are the result of reflection forming return waves. In sound, as in other forces, the angle of reflection equals the angle of incidence. Sound is also refracted, by passing through media of differing densities. The distance of an echoing surface can be estimated by multiplying the number of seconds before the echo is heard by 550 feet.

Pitch depends upon the number of vibrations per second. The limit of perceptible sounds is from 16 per second for deep sounds, to 60,000 per second for high sounds. The human voice ranges from 100 to 1000 vibrations per second. The range of sounds used in music extends from 40 to 4000 vibrations per second. Vibration-frequency in pipes varies inversely as the length; open pipes are twice as long as closed pipes of the same pitch. The vibration-frequency of strings of the same material varies inversely as the length and the square root of the weights, and directly as the square root of the tension. The siren is an instrument for the determination of vibration-frequency.

Middle C has 256 or 264 vibrations per second. Each octave contains double the number of vibrations of the one just below it, and one-half of that above. If the ratio of intervals of three notes is 4:5:6 they form a harmonic triad. If to these three a fourth note, the octave of the first one, is added, we have a major chord. In a minor chord the ratio is 10:12:15, with the octave of the first note. Quality, or timbre, varies with the nature of sound-producing bodies, and depends on the form of vibrations due to the combination with fundamental tones of harmonics or overtones: *i.e.*, the sounds produced by the vibration of an instrument in parts.

The musical scale is made up of gamuts or series of notes connecting octaves. These notes are represented by the letters C, D, E, F, G, A, and B. If the vibrations of C be represented by 1, those of D are $\frac{9}{8}$; of E, $\frac{5}{4}$; of F, $\frac{4}{3}$; G, $\frac{3}{2}$; A, $\frac{5}{3}$; B, $\frac{15}{8}$; and the octave C, 2. The larger intervals ($\frac{9}{8}$ and $\frac{10}{9}$) between these notes, obtained by dividing the larger fractions by the smaller, are termed tones; the smaller interval ($^{16}/_{15}$), semitones.

Interference of sounds may intensify or nullify motion, according as the hollow of one wave fits in the hollow or the crest of another; just as we may produce darkness by adding light waves to others. The wavy sounds produced by interference are called beats; the number per second from two simple notes equals the difference of their vibration numbers. Interference in cords commonly results in vibrations in loops or segments: the points of least vibration are called nodes; the points of greatest motion, antinodes. Sympathetic vibrations are those produced in a body by the vibrations of another body near by. They are termed forced vibrations when the body acted on was already in vibration, but was made to assume the vibration-period of the other.

The ear, or organ of hearing, is designed to gather and convey sound-waves by vibrations of the tympanum and the chain of bones in the middle ear, to the vestibule and cochlea of the inner ear. The organ of Corti consists of about 3000 minute bristles of various lengths, suspended in the liquid here; they "take up and analyze the vibrations, much as when we sing into a piano with the damper down, only those strings respond which are in unison with the sound produced by the voice." These bristles are connected with nerve-filaments, which transmit the sensory impressions to the auditory center of the brain. The range of the ear for pitch is eleven octaves, as contrasted with the single octave which the eye has for colors. With advancing age the higher sounds become inaudible.

The larynx, or voice-box, is "a reed instrument situated at the top of the windpipe, or trachea." The elastic vocal cords are stretched across the orifice: laxly when breathing, more tight during vocal action. Tension is regulated by muscular action, and, the tenser the cords, the higher the pitch. The mouth and nasal passages serve as resonators, and change shape in accordance with vocalization and articulation. "Chest notes" are produced by vibration of vocal cords as a whole; falsetto notes by vibration of the free edges. Two octaves is the average extent of scale of the human voice. The wave length of voice in women during ordinary conversation is 2 to 4 feet; in men, 8 to 12 feet. Different vowel sounds are due to various admixtures of the fundamental tone and the overtones of the voice, as produced by altering the shape of the lips, the position of the tongue and the size of the oral cavity.

The tuning-fork is an instrument much used in the differential diagnosis of ear-troubles. In testing bone-conduction it is placed with the end of the handle resting at a right angle on the mastoid or vertex. Air-conduction is normally superior to bone-conduction, and the fork held before the meatus should be heard twice as long as on the mastoid; or if the vibration ceases to be audible on the bone it should still be heard at the orifice of the auditory canal. When the fork is heard longer by bone-conduction, the canal or the middle ear is affected. In labyrinthine disease the impairment of hearing is the same for air- and for bone-conduction. The tuning-fork can be used similarly in the diagnosis of fractures of the long bones.

The phonograph consists essentially of a metal cylinder rotated by a crank and covered with wax composition and threaded like a screw; over the furrow is set a vibratory style at the bottom of the mouth-piece. Every movement of the style caused by the voice is thus recorded by impressions in the wax, and if the cylinder is brought back to its original position and turned as before, the style will play up and down over the depressions and ridges, and so reproduce the spoken words.

The audiphone is a fan-shaped sheet of ebonite or elastic cardboard held between the teeth of persons partially deaf, to aid them in hearing.

QUESTIONS ON MEDICAL PHYSICS.

1. Mention a form of matter perceived by smell, but not by sight; one recognized by feeling, and not by sight.

2. Distinguish between a physic and a chemic change, and mention an example of each.

3. Distinguish between volume, mass, and density.

4. Name the three chief metric units, and explain their mutual relations.

5. Read the following: 0.025 m.; 25.365 gm.

6. Write as one number, 1 kgm. and 1 mgm.

7. How many grams in a dram? In an ounce?

8. What is the length in English measure of a meter? Of a millimeter? Of a micromillimeter?

9. What is the capacity in English measure of a liter?

10. How many milligrams in a kilogram?

11. Write a metric prescription for a 2-ounce mixture, teaspoonful doses, using the following drugs and doses: Potassium acetate, gr. x; salicylic acid, gr. xx; water, to fill the bottle.

12. What difference between a Troy, or apothecary's, ounce and an avoirdupois ounce? Same as to pound?

13. Does a pint of water weigh a pound?

14. What difference, if any, between a minim and a drop?

15. How many grains of corrosive sublimate to the pint of water in making a 1 to 1000 solution?

16. A 4-per-cent. solution of cocain contains how many grains to the ounce?

17. How do high altitudes mechanically help weak lungs?

18. What is the use of the spout of a pitcher?

19. If a body is of the same sp. gr. as water, where does it float?

20. Is the sp. gr. of water at ordinary temperature below or above 1?

21. What effect does the addition of water to alcohol have on the sp. gr. of the latter?

22. A piece of brass weighs 37.71 gm. in air, 32.21 in water. Find its sp. gr.

23. A piece of metal weighs 40 gm. in air, and displaces a trifle

more than 2 c.c. of water. What is the approximate sp. gr. of the body, and of what metal is it composed? (See table.)

24. The sp. gr. of caustic potash is 2.1. About what is the sp. gr. of a 10-per-cent. solution in water?

25. What is the approximate strength of a solution of dilute sulphuric acid (sp. gr., 1.40)?

26. Why are gases more compressible than liquids or solids?

27. What is the sp. gr. of a lump of sugar weighing 20 gm. in air and 9 gm. in oil of turpentine (sp. gr., 865)?

28. Why is water stale after boiling?

29. Why is it difficult to push an inverted tumbler directly downward into a vessel of water?

30. Why does a string attached to and capable of holding up a weight break suddenly when jerked? (Fractures of the patella and other bones have been caused by muscular action.)

31. Why do bubbles appear on a glass plate immersed in water?

32. Why does quicksilver not wet the fingers?

33. Give an example of each of the four kinds of elasticity.

34. Why are cables stronger than chains of the same size.

35. What difference in weighing with scales at sea-level and at high altitudes?

36. What is the volume of a liter of hydrogen (at ordinary pressure) when subjected to a pressure of 100 atmospheres?

37. Twelve liters of oxygen at standard temperature and pressure undergo what change in volume at a temperature of 60° C. and a pressure one-fourth less? $(12.000 \times {}^{333}/_{273} \times {}^{760}/_{570}.)$

38. Oxygen is 16 times as dense as hydrogen. What is their diffusion-ratio?

39. Explain nosebleed on ascending high mountains.

40. Explain the weather-changes of the barometer.

41. What is the siphonage-force in grams of a siphon 2 cm. in caliber, the long-arm sine being 40 cm., and the sine of the short arm 15 cm.?

42. How does charcoal act as a deodorizer?

43. Why is it easier to descend the stairs than to ascend them?

44. Define and give an illustration of the principle of the correlation and conservation of energy.

45. Explain the relationships of heat, light, and electricity.

46. Why do people in warm countries wear light-colored clothing?

47. Why do muddy roads dry more quickly in windy weather?

48. What time of day, as a rule, is the relative humidity of the atmosphere greatest?

49. Why does the wind often go down with the sun?

50. Why is it more often cloudy morning and evening than in the middle of the day?

51. Contrast the direction of the air-currents at the top and the bottom of an outside door in winter and summer.

52. Why is frost more likely to be seen after a clear than a cloudy night?

53. Why is mercury preferred to water for thermometers and barometers? About how high would the water-column stand in a water-barometer?

54. State the normal temperature of the human body (mouth) in F. and in C. readings.

55. Change —40° F. to the centigrade scale.

56. Why are the rails on a railway not joined together more closely? The height of Eiffel's tower (989 feet) varies 8 inches during the year.

57. The altitude of Denver is exactly one mile. What is the b.p. (centigrade) of water in that city?

58. Which has the higher b.p., fresh water or sea-water?

59. Which warms more quickly, ice or water?

60. Why is damp cold more chilling than dry cold?

61. How distinguish between a physic and a chemic solution?

62. Name a solid substance which aids in the solution of another.

63. Why is sterilization of surgical supplies more effective with steam heat than with dry heat?

64. If we mix a pound of water at 80° with another pound at 0°, what is the temperature of the mixture? Suppose, in the second case, we use a pound of snow or ice, what then?

65. How many pounds of water would a pound of steam (at 100°) raise from the f.p. to the b.p.?

66. Which would be more affected by sudden thermal changes, a roughly-finished or a highly-polished dental filling?

67. What causes borax and many other salts to swell upon heating?

68. What is the temperature of water at the bottom of a pond in winter?

69. Where is the warmest air in a room, and why?

70. Is the heat of the body mostly mechanic or chemic in origin?

71. Why are the nights comparatively cooler in dry, high climates?

72. Why do thick glass vessels break when suddenly heated or cooled?

73. Why not use alcohol for cleansing varnished surfaces?

74. Distinguish between deliquescence and efflorescence.

75. Explain steam-heating.

76. What liquid boils at about temperature of the body?

77. Why does early frost appear on some objects and not on others?

78. What causes "sweating" of ice-water pitchers?

79. Explain principle of glass hotbeds.

80. How does vinegar- or alcohol- sponging cool our bodies?

81. Why is our breath visible in winter?

82. Why is it nearly always cooler when the wind blows?

83. How is the straight rising of smoke a sign of fair weather?

84. Is more heat used up in melting ice or in boiling water?

85. Name the three manifestations of radiant energy.

86. Why cannot one see around a corner?

87. Explain, with diagrams, how a too short antero-posterior diameter of the eyes causes far-sight, and a too long diameter near-sight. (Rays of light are refracted by the crystalline lens, crossing each other a little behind the lens, so that the retinal image is an inverted one.)

88. How does polarized light differ from ordinary light?

89. What is the wavy motion seen around stoves in winter?

90. Why does a street appear to grow narrower farther away?

91. Why does the rising sun or moon look larger?

92. Name and explain the three kinds of spectra.

93. Why do electric cars run better in fair than in stormy weather?

94. Name and define the three chief units of current electricity.

95. Compare the electric resistance of the skin with that of the Atlantic cables.

96. Which electrode has a drying action, and which a softening effect, and why?

97. What causes the compass to point north and south?

98. Mention the chief differences between the galvanic and the faradic current.

99. Why does the faradic hand-cathode feel stronger than the anode?

100. Why does acidulated water break up more easily by electrolysis than pure water does?

101. Distinguish between osmosis and dialysis.

102. Why do sodium chlorid solutions exert a greater osmotic pressure than an equivalent strength of a sugar solution?

103. What are isotonic, hypertonic, and hypotonic solutions?

104. Name the six systems of crystals, and mention an example under each.

105. To what is the color of most crystals due?

106. Why are sounds less intense on a mountain than in a valley?

107. How does a common cold change the voice?

108. If a flash of lightning is followed in five seconds by the thunder, what is the distance?

109. What are the three principal properties of sound, and on what do they depend?

110. How does stoppage of the Eustachian tube cause partial temporary deafness?

111. How distinguish between deafness due to external-, to middle-, and to internal- ear disease?

112. Why are distant noises heard better at night, and also often before a storm?

113. How do ear-trumpets, stethoscopes, and megaphones aid hearing?

114. How many degrees will the air of a room containing 1000 cubic feet be raised by passing in a kilogram of live steam?

115. Explain how, when the front of the eye has a greater curve in one meridian than in others, vertical and horizontal crosslines are seen with unequal distinctness. (Astigmatism.)

116. Given equimolecular solutions of common salt and sugar, which has the lower f.p.?

117. Why do dwellers in the tropics wear white clothing, and red and yellow underneath?

118. Why is electric lighting more healthful than illuminating gas?

119. Why cannot one see well in going from a dark place into a bright one, or *vice versa?*

120. Why does a rapidly-revolving wheel look like a solid disk? (Any image formed on the retina and conveyed to the brain lasts about 1/8 second.)

121. Why does the filament of the incandescent lamp appear much wider when aglow than when cold?

122. Why does a red cloth appear brighter than one of any other color?

123. Which will keep warm longer, a bag of hot water, or a sack of salt of the same weight, heated to the same temperature as the water?

124. Why does blue look greenish by lamplight?

125. Why can one tell an acquaintance by his voice?

126. Why does the anode stick to mucous membrane, while the cathode passes more readily, after using the constant current?

127. Why does the anode corrode and waste away when used on mucous membranes as the active electrode?

128. How does taking salt aid in checking hemorrhages?

129. What effect on the blood-corpuscles has the injection of distilled water into the blood?

130. A mole of sodium chlorid dissolved in a liter of water has a Δ of 3.35. What is the isotonic coefficient?

131. Does the isotonic coefficient increase or diminish with dilution of a salt solution?

132. Which pole of the arc light wastes more rapidly?

133. In the arc light, which pole of carbon takes on a crater form, which becomes conical, and why?

134. A 16-candle power Edison lamp requires 0.6 ampère, or 102 volts; what is the resistance?

135. Explain the physics of freckles.

136. How many ergs are required to lift 1 gm. through 1 cm?

137. Is paper a good or poor conductor of heat and cold?

138. What relation in C. and F. degrees does the lowering of b.p. with altitude bear to the reading of the barometer in inches?

139. How may a wind be rendered warmer by coming over a mountain into a valley?

140. What causes ebullition on boiling a liquid, and how may it be prevented?

141. How could you light a fire with a piece of ice?

142. Mention a test of death by the use of light.

143. Why are colors usually more fast in wool than in cotton?

CHEMIC PHILOSOPHY.

ELEMENTS.

An element is a substance composed of only one kind of matter. Iron, gold, hydrogen, and oxygen are elements. Chemic compounds are made up of more than one kind of matter. Water is a compound substance, since it can be decomposed by electrolysis into hydrogen and oxygen. A definite compound always contains the same elements in the same proportion.

The properties of different substances depend upon their elements and the ways in which these elements are combined. There are about 80 elements known at the present time, 12 of which at ordinary temperatures are gases, 2 liquids, and the remainder solids. By far the greater number are metals; the non-metallic elements are often termed metalloids. The names of the elements are generally Latin (metals end in *um*; non-metals, *in* or *on*), and indicate some peculiar or fancied property. Some of the well-known elements have both an English and a Latin name; the majority of these were known to the ancients.

According to recent views, chemic elements are merely "residues left after ages of disintegration," similar to that which radium and other transition forms are now undergoing. The intermediate substances produced by decomposition of elements are termed metabolons, and constitute, says Soddy, "the temporary halting places through which matter is passing in a scheme of slow, continuous evolution from the heavier to the lighter forms." Originally, what we now know as the elements may have been condensed from the hypothetic protyle (Crookes) by a different orbital arrangement of the primordial electrons.

"The alchemists assumed that Nature must be simple. Chemists have proved that Nature is infinitely complex; but amid this vast complexity they have detected, they are detecting, certain broad lines of unity."

The symbol, or sign, of an element is made up of the initial and sometimes another distinctive letter from the Latin name: *e.g.*, C for carbon, Ca for calcium, Cl for chlorin, Cu for copper (Latin, *cuprum*), etc.

TABLE OF ELEMENTS.

NAME.	SYMBOL.	VALENCE.	ATOMIC WEIGHT.	USUAL POLARITY.
Aluminum	Al	III	26.9	+
Antimony	Sb	III, V	119.6	—
Argentum (see "Silver").				
Argon	A	O	39.6	
Arsenic	As	III, V	74.45	—
Aurum (see "Gold").				
Barium	Ba	II	136.4	+
Beryllium	Be	II	9.03	
Bismuth	Bi	III	206.5	+
Boron	B	III	10.9	—
Bromin	Br	I, III, V, VII	79.34	—
Cadmium	Cd	II	111.5	+
Calcium	Ca	II	39.8	+
Carbon	C	II, IV	11.9	—
Cerium	Ce	III, IV	138.0	+
Cesium	Cs	I	132.7	+
Chlorin	Cl	I, III, V, VII	35.18	—
Chromium	Cr	II, III, VI	51.7	—
Cobalt	Co	II, III	58.6	+
Columbium	Cb	V	93.7	—
Copper	Cu	I, II	63.18	+
Coronium	Cm			
Erbium	Er	III	166.0	+
Ferrum (see "Iron").				
Fluorin	F	I	19.0	—
Gadolinium	Gd	III	156.1	+
Gallium	Ga	III	69.9	+
Germanium	Ge	II, IV	72.3	+
Glucinum (see "Beryllium").				
Gold	Au	I, III	196.7	+
Helium	He	O	4	
Hydrargyrum (see "Mercury").				
Hydrogen	H	I	1.0	+
Indium	In	II (In_2 = VI)	113.6	+
Iodin	I	I, III, V, VII	125.89	—
Iridium	Ir	II, IV, VI	192.5	+
Iron	Fe	II, III	55.88	+
Kalium (see "Potassium").				
Krypton	Kr	O	81.2	
Lanthanum	La	III	138.2	+
Lead	Pb	II, IV	205.36	+
Lithium	Li	I	6.97	+
Magnesium	Mg	II	24.1	+
Manganese	Mn	II, III, IV	54.6	+
Masrium	Ms		228.0	
Mercury	Hg	I, II	198.5	+
Metargon			40.0	
Molybdenum	Mo	II, IV, VI	95.9	—
Natrium (see "Sodium").				
Neodymium	Nd	III, IV	140.5	

TABLE OF ELEMENTS (*Continued*).

NAME.	SYMBOL.	VALENCE.	ATOMIC WEIGHT.	USUAL POLARITY.
Neon	Ne	O	20.0	
Nickel	Ni	II, III	58.6	+
Niobium (see "Columbium").				
Nitrogen	N	I, III, V	13.93	—
Osmium	Os	II, IV, VI, VIII	190.3	+
Oxygen	O	II	15.88	—
Palladium	Pd	II, IV	106.35	+
Phosphorus	P	III, V	30.75	—
Platinum	Pt	II, IV	194.3	+
Plumbum (see "Lead").				
Potassium	K	I	38.82	+
Praseodymium	Pr	II	143.5	+
Radium	Ra	II	223.0	+
Rhodium	Rh	III	102.9	+
Rubidium	Rb	I	85.2	+
Ruthenium	Ru	II, IV, VI, VIII	101.4	+
Samarium	Sm	III, V	149.6	+
Scandium	Sc	III	43.9	+
Selenium	Se	II, IV, VI	78.9	—
Silicon	Si	II, IV	28.2	—
Silver	Ag	I	107.89	+
Sodium	Na	I	22.88	+
Stannum (see "Tin").				
Stibium (see "Antimony").				
Strontium	Sr	II, IV	86.95	+
Sulphur	S	II, IV, VI	31.83	—
Tantalum	Ta	III, V	182.0	—
Tellurium	Te	II, IV, VI	125.0	—
Terbium	Tb	III	159.1	+
Thallium	Tl	I, III	203.7	+
*Thorium	Th	IV	230.8	+
Thulium	Tu	III	170.7	+
Tin	Sn	II, IV	118.1	+
Titanium	Ti	II, IV	48.0	—
Tungsten	W	II, IV, VI	183.6	—
Uranium	U	II, IV, VIII	239.5	+
Vanadium	V	III, V	51.1	—
Wolfram (see "Tungsten").				
Xenon	Xe		128.0	
Ytterbium	Yb	III	172.6	+
Yttrium	Yt	III	88.9	+
Zinc	Zn	II	64.9	+
Zirconium	Zr	II, IV	90.4	+

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* Baskerville has resolved thorium into two new elements, one of which he has named carolinium (after his State), the other berzelium (in honour of the Swedish chemist who discovered thorium).

ATOMS AND THEIR PROPERTIES.

An atom is the smallest indivisible particle of matter that can take part in a chemic change. Atoms do not usually exist separately, but are held together by chemism, or chemic affinity (polarity), so as to form molecules. A molecule may therefore be defined as the smallest portion of matter that can exist in a free state, or into which matter can be divided by physic means.

When the constituent atoms of molecules are alike, we have a simple, or elemental, molecule; when the atoms are unlike, a compound molecule. Simple molecules make up elements; compound molecules, compound substances.

An element in the free, nascent, unsaturated, or atomic state has a more powerful action on other substances than when in combination, since no force is spent in breaking up existing molecules. Free atoms have no polarity until they enter into combination.

Labile chemic compounds are unstable bodies, and readily undergo chemic change: either a disruption of the molecule or a new intramolecular arrangement of atoms, which tend to migrate to a more stable position. The term stabile indicates the reverse of labile. Potential, or static, labile compounds include the explosives, such as nitroglycerin. These are commonly rich in O. Chemic changes destroy static labile compounds, whereas dynamic, or kinetic, labile compounds pass into polymeric or isomeric compounds: *i.e.*, the atoms take on a different arrangement within the molecule, or several like molecules are fused together into one. Compounds have properties of their own distinct from those of their constituent elements.

ATOMICITY.

It has been determined by careful experiments (Raoult's method of depression of freezing point, using melted tin as a solvent), that most elemental molecules are diatomic: *i.e.*, they contain two atoms. Ni, Ag, Cu, Mg, Pb, B, Hg, Cd, Zn, Ca and Ba are monatomic; Se and O (ozone), triatomic; As and P, tetratomic; S (below 550°), octoatomic (becomes quadridiatomic at 1000°). C probably has a considerable atomicity. Colloid molecules have more atoms than crystalloid; hence are larger. The physic properties of substances vary greatly according to the method of atomic linking, which in true chemic compounds is always an unbroken system. The different forms and properties which some elements assume according to the ways in which their constituent atoms face each other in the molecule is termed allotropic. In chemic nomenclature the symbol of an element represents also one atom of the element.

According to some authorities, atoms themselves are definite collections of from several hundred (H, 700; O, 11,200) to many thousand electrons, or units of electricity, on which their polarity and radioactivity depend. It is a noteworthy fact that all elements with atomic weight over 200 are radioactive.

ATOMIC WEIGHTS.

The actual weight of the atom of any element is, of course, an imponderable quantity, but the relative weights of elemental atoms is easily determined by comparing the weights of equal volumes of these elemental substances in the gaseous state and at the same temperature and pressure, making due allowance for atomicity. When elements cannot be volatilized, the atomic weight is computed from the density of their gaseous compounds. The atomic weight of any element is the weight of an atom of the element as compared with the weight of an atom of H, taken as the unit, or 1. The atomic weight, for instance, of O is approximately 16; of Br, 80; of Na, 23. Elements are liberated by electrolysis in proportion to their atomic weights.

The density, or relative mass, of an element is equivalent to the atomic weight, providing both elements compared have the same number of atoms to each molecule. For example, O and H both contain 2 atoms in the elemental molecule; hence the density of O is 16. Hg, on the other hand, has an atomic weight of nearly 200, and contains only 1 atom to the molecule; its density is, therefore, one-half of 200, or 100. Briefly stated, the density is half the molecular weight, by which is meant the sum of the weights of all the atoms in a molecule. Substances containing H have a comparatively low density.

It is necessary to know the atomic weights (combining equivalents) of the different elements in making most chemic calculations. For most ordinary purposes fractions are disregarded and the nearest whole numbers employed. Atomic weights are inversely proportional to the specific heats of elements, or, in other words, the atoms of the various elements have equal capacities for heat. The product of the specific heat of any element by its atomic weight gives a nearly constant quantity: namely, 6.5. O, H and N are possessed of great atomic heat. Elements of the same class vary in potency directly with their atomic weights; hence it is a law that "the properties of an element are a periodic function of its atomic weight."

The molecular volume of a gas equals the product of the specific volume and molecular weight. The molecular heat of a substance equals the product of its specific heat and molecular weight, or, in solids, the sum of atomic heats of its elements. The molecular heat of gases diminishes with lowering of temperature. The molecular heat of vaporization of a liquid is the product of the heat of vaporization and the molecular weight; *i.e.*, the amount of heat in calories required to convert one mol of the substance into vapor of the same temperature as the liquid.

POLARITY.

As already stated in the section on physics, when an electrolyte is decomposed by electrolysis, the metal or + element (cation) clings to the — pole, while the — element or part (anion) is set free at the + pole. Metals are, therefore, electropositive in nature; metalloids, electronegative. Yet this classification is relative and a question of degree: some metals are more positive than others; some metalloids more negative than other non-metals. O is the most — of elements; Cs, the most +.

The following short list, comprising the more common elements, represents this relationship, each element being + to the ones which precede and — to those that follow: O, S, N, Cl, Br, I, P, As, B, C, Sb, Si, H, Au, Pt, Hg, Ag, Cu, Bi, Sn, Pb, Co, Ni, Fe, Zn, Mn, Ce, Al, Mg, Ca, Sr, Ba, Li, Na, K, Cs.

In chemic compounds plus and minus elements are combined, and the wider the difference in their polarity, the greater the attraction between them, and, generally speaking, the stronger the combination.

Experiment.—Cut a piece of the metal K, and note how quickly the cut surface whitens (oxidizes). Throw a fragment on a basin of water. This is decomposed by the K, which takes up O and sets free H (burns with a violet flame, in this instance).

When two elements of the same family are capable of combining directly with each other, the one having the higher atomic weight takes the positive rôle. H and B invariably take the positive rôle in combining with other elements, as do most metals. O and F are always negative in their compounds. Atoms of C, N, and P may have both + and — bonds concurrently. The polarity of the atoms in an elemental molecule must be the converse of each other: that is, + and — (divided polarity). When such a molecule enters into a chemic change, both atoms become of like polarity: that is, + or —. H has a reducing power of 2 units, because in combining with other elements its negative atom rises in polarity from — 1 to + 1: an algebraic difference of 2. In combinations of C, H, and O the C bonds united to H are negative; those joined with O are positive. A, He, Kr, Ne and Xe form no compounds.

VALENCE.

This is a very important subject, without which chemic nomenclature can never be really understood. Valence (equivalence, quantivalence) signifies the combining or replacing power of an element as compared with H taken as the unit. Those elements which combine with or replace H atom for atom are called monads. Such as require 2 atoms of H to satisfy, or saturate, or neutralize the polarity of 1 atom of the given element are termed diads. The triad atom replaces or combines with 3 of H or any other monad; the tetrad, 4 (or 2 diads); the pentad, 5; the hexad, 6; the heptad, 7; the octad, 8. The Latin adjectives corresponding with these Greek substantives are univalent, bivalent, trivalent, quadrivalent, quinquivalent, sexivalent, septivalent, and octivalent. Artiads are elements with an even valence; perissads, uneven. Monogenic is a term sometimes applied to monads; polygenic, to all other elements. The law of even numbers is that in all saturated molecules the sum of the perissad atoms is always even, and molecules composed of perissad elements contain an even number of atoms. A diad element, or radical, can be introduced into a compound without altering the valences of other elements: *e.g.,* K — O — K and K — O — O — O — O — K.

It will be noticed that a good many elements have more than one valence, the series differing by 2, as a rule. The higher valence is shown only when the element is acting the + rôle in connection with O, which, on account of ultranegativity, seems to draw out the full polarity of the more positive element with which it is combined. Valences vary also with temperature and with unknown conditions. The valence of an element may differ in the same compound, as in the formula, NH_4CNO.

The following table shows at a glance the usual valence of each of the more common elements:—

MONADS.	DIADS.	TRIADS.	TETRADS.	PENTADS	HEXADS.	HEPTADS.	OCTADS.
F	O	Cl	S	Cl	S	N	Os
Cl	S	N	C	N	Cr	Cl	Ru
Br	Hg (ic)	P	Si	P	Mn		
I	Cu (ic)	As	Pt	As			
H	Pb	B	Sn (ic)				
Ag	Cd	Sb					
Li	Co	Au					
Na	Ni	Bi					
K	Fe (ous)	Co					
Hg (ous)	Cr (ous)	Fe (ic)					
Cu (ous)	Mn (ous)	Al					
	Zn	Cr					
	Mg						
	Ca						
	Sr						
	Ba						
	Sn (ous)						

The valence of an element can be indicated in one of three ways: 1. By Roman numerals placed above the symbol and to the right; as, H^{I}, O^{II}, N^{III}, C^{IV}. 2. By single dashes representing double (positive and negative) bonds of union, or points of attraction, or poles of the atomic magnet; as, H —,

$—O—$, $N\equiv$, $=C=$. 3. By accent marks written to the right and above the symbol; as, Cl′.

Exercise.—Practice on combining the positive with the negative elements of the table above, according to their valence, writing the positive element's symbol first. For example, $NaCl$, PbI_2, $AuCl_3$, SO_2, P_2O_5.

Expressed according to the electronic theory, the valence of an element is the number of electrons gained (negative) or lost (positive) in order for the atom to become stable or reach equilibrium.

The true combining value, or polarity value, of any atom in combination is the algebraic sum of its + and — bonds. An atom having 3 negative bonds, and another having 3 positive bonds, are of equal valence, but the difference in their respective polarity-value is 6. Thus, $KMnO_4$ has an oxidizing power of 5 units, since the difference in polarity between Mn in this compound and Mn in the reduced (deoxidized) manganese compound is 7 — 2, or 5. The lowest possible polarity value is — 4; the highest polarity value, + 8; but the difference between the highest and the lowest polarity-value in the same atom never exceeds 8 units. The algebraic sum of the + and — bonds holding any two or more atoms together is zero. Any increase or diminution in the polarity-value of any atom or group is always accompanied by an equal converse diminution or increase in the combining atom or group. Increase of polarity-value is termed oxidation; decrease of polarity value, reduction. Oxidizing agents are atoms or groups that will sustain a diminution of polarity value; reducing agents are atoms or groups that can gain in polarity value. Free, or nascent, O is an oxidizing agent, because when it enters into combination with other elements it acquires 2 negative bonds. Free, atomic H is a reducing agent for the converse reason. Unsaturated compounds can enter directly into combination with other elements or compounds. According to Loeb, the higher the valence of cations the greater is their activity on solutions of electrolytes.

Gay-Lussac's law states that volumes of gases entering into chemic union hold a simple relation to each other, the compound gas resulting usually having the volume of two, even when the original single volumes were three or four. Thus one volume N + three volumes H = two volumes NH_3. Dalton's law is that a definite chemic compound always contains the same elements united in the same proportions (law of multiple proportions). As a corollary to this, the law of equivalent proportion asserts that the proportions in which any two elements unite with a third are the same in which they unite with each other. The chemic equivalent, or equivalent weight, equals the atomic weight divided by the valence. Gram-equivalent is the weight of a molecule in grams divided by the valence.

MOLECULES AND FORMULAS.

The molecule has already been defined as the smallest portion of matter that can exist in a free state, or independently. Homogeneous masses are made up of like molecules. When the atoms composing a molecule are alike, the molecule is simple, or elemental; when the atoms are unlike, they form a compound molecule.

A radical or residue is an atom or a group of atoms common to a number of compounds. A single atom constitutes a simple radical; a group of unsaturated atoms, a compound radical. For example, the Na atom is a simple radical, characteristic of all sodium compounds; HO is a compound radical present in every hydrate. Compound radicals may be regarded as residues left on removing one or more atoms from a saturated molecule; thus, HO, hydrate, is derived from H_2O by dropping one atom of H. The valence of most compound radicals is easily determined by subtracting the sum of positive polarities from the sum of the negative polarities, or *vice versâ.*

The following table of compound radicals and their valences should be learned by heart:—

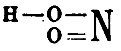
MONADS.	DIADS.	TRIADS.	TETRADS.
NH_4 — ammonium	Hg_2 = mercurous	Fe (ic)	SiO_4 = silicate
CH_3 — methyl	Cu_2 = cuprous	Mn (ic)	P_2O_7 = pyrophosphate
C_2H_5 — ethyl	S_2O_3 = thiosulphate	Cr (ic)	$Fe(CN)_6$ = ferrocyanid
HO — hydrate	SO_3 = sulphite	Al (ic)	
CN(Cy) — cyanid	SO_4 = sulphate	BO_3 = borate	
NO_2 — nitrite	CO_3 = carbonate	AsO_3 = arsenite	
NO_3 — nitrate	C_2O_4 = oxalate	AsO_4 = arsenate	
ClO — hypochlorite	CrO_4 = chromate	$C_6H_5O_7$ = citrate	
ClO_2 — chlorite	Cr_2O_7 = dichromate	PO_4 = phosphate	
ClO_3 — chlorate	$C_4H_4O_5$ = malate	$Fe(CN)_6$ = ferricyanid	
ClO_4 — perchlorate	$C_4H_4O_6$ = tartrate		
PO_3 — metaphosphate	PHO_3 = phosphite		
PH_2O_2 — hypophosphite	B_4O_7 = tetraborate		
$C_2H_3O_2$ — acetate	MoO_4 = molybdate		
$C_3H_5O_3$ — lactate	WO_4 = tungstate		
$C_5H_9O_2$ — valerianate			
C_6H_5O — carbolate			
$C_7H_5O_2$ — benzoate			
$C_7H_5O_3$ — salicylate			
$C_{14}H_9O_9$ — tannate			
$C_7H_5O_5$ — gallate			

A formula is a combination of symbols representing a molecule, as NaCl, which stands for a molecule of sodium chlorid, made up of an atom each of Na and Cl. H_2O is the formula of hydrogen oxid, or water, which is composed of 2 parts of H and 1 of O. In writing formulas we place the + element, or radical, always first, the — element, or radical, following, taking care that the valence of each is satisfied. The multiplication of atoms is shown by small figures written to the right and below the symbol, as in H_2O or $HgCl_2$. Compound radicals taken a number of times are inclosed in parentheses; thus: $(NH_4)_2SO_4$. Two or more molecules of a compound are designated by a large figure, or coefficient, written before the formula; thus, $5H_2O$ represents five molecules of water.

Exercise.—Practice in notation of formulas with the aid of the two preceding tables. For example, H_2SO_4, $Na_2B_4O_7$, $FeCl_3$.

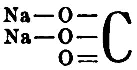
A graphic, structural, or rational formula differs from the ordinary empiric formula in that the arrangement and relation of atoms to each other in a molecule are shown pictorially. In other words, not only the composition, but the constitution, as well, of the compound is shown. Graphic formulas are of great interest and importance in organic chemistry. They are based upon a study of the chemic conduct of compounds, and the bonds of union are usually indicated by dots or dashes. The following are examples:—

H—O—H for H_2O;



$$\begin{array}{l}H—O—\\ \quad\;\; O{=}\end{array}N$$

for HNO_2;



$$\begin{array}{l}Na—O—\\ Na—O—\\ \qquad\; O{=}\end{array}C$$

for Na_2CO_3

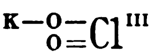
The nomenclature of chemic compounds is simpler and more definite than it formerly was. Binary compounds (those containing but two elements directly united, or a positive compound radical and a negative element) are read by naming with its proper name the positive element or radical, and then the negative element with its ending changed to *id* (or *ide*): *e.g.*, NaBr, sodium bromid; KI, potassium iodid, etc.

Exercise.—Write formulas and name ten binary compounds.

Ternary compounds (those containing more than two elements, indirectly united, or more than a — element and a + radical) are named according to the table of radicals given above. It will be seen, as per the following graphic formulas, that the ending *ate* indicates a higher valence of the negative element than does *ite*, and still higher in *per*—*ate*, while its lowest valence is expressed by *hypo*—*ite*.

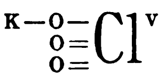
Potassium hypochlorite

$K—O—Cl^{I}$



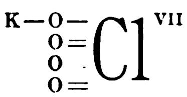
Potassium chlorite

$$\begin{array}{l}K—O—\\ \quad\;\; O{=}\end{array}Cl^{III}$$



Potassium chlorate

$$\begin{array}{l}K—O—\\ \quad\;\; O{=}\\ \quad\;\; O{=}\end{array}Cl^{V}$$



Potassium perchlorate

$$\begin{array}{l}K—O—\\ \quad\;\; O{=}\\ \quad\;\; O\\ \quad\;\; O{=}\end{array}Cl^{VII}$$

Exercise.—Write formulas and name ten ternary or quaternary compounds.

The + as well as the — elements sometimes differ in valence in different compounds. The higher valence is distinguished by changing the end of the name of the positive element to *ic*; the termination *ous* is characteristic of the lower valence.

The formulas of acid substances are readily formed by prefixing the requisite number of H atoms to the corresponding radical: to the monad radical 1 H; to the diad, 2, etc. Thus, the radical for nitrite is NO_2, the formula for nitrous acid HNO_2; the radical for nitrate is NO_3, the formula for nitric acid is HNO_3. Again, SO_4 is the diad radical for sulphate, and H_2SO_4 the formula for sulphuric acid.

Exercise.—Write and name all the acid formulas that can be formed from the radicals ending in *ate* or *ite* in the table above.

There are some irregularities in chemic nomenclature arising from the old system and occasionally met with in medical literature. The most important of these anachronisms are the use of the prefixes *per* for the suffixes *ic* and *ate,* and of *proto* for *ite* or *ous.* The prefixes *mon, di* or *bi, tri* or *ter, tetra,* and *penta* are often employed to indicate the number of atoms of a given element in a compound, as CO_2, carbon dioxid; $HgCl_2$, the bichlorid of mercury; N_2O_3, nitrogen trioxid.

The oxids of some of the metals are sometimes named by simply changing the *um* termination of the name of the metal to *a*; as Na_2O, soda; MgO, magnesia; and SrO, strontia. Many oxids of non-metallic elements unite with H_2O to form acids, and on this account are known as anhydrids; thus, P_2O_5 is called phosphoric anhydrid, and CO_2, carbonic anhydrid.

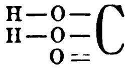
The ferric salts were formerly termed the sesquioxid, sesquichlorid, etc. The proper names of compound radicals commonly terminate in *yl,* as CO, carbonyl; COOH, carboxyl; HO, hydroxyl or oxhydryl or simply ol; BiO, bismuthyl; NO_2, nitroxyl; and SO_2, sulphuryl. The popular names of common compounds do not generally express their composition, but more often the place of origin or some physical peculiarity; for example, ammonia, marsh-gas, sewer-gas, and oil of vitriol. Water of crystallization is shown by the + sign or a period before H_2O.

ACIDS, BASES, AND SALTS.

The function of a substance includes its chemic character and relationships—acid, base, salt, etc.

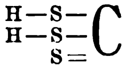
An acid is a chemic compound consisting of a negative element (rarely metals) united to H either directly or by means of linking O or S. If the union is direct, we have what is called a hydracid; if by the medium of O as a connecting agent, an oxyacid; if S is the linking agent, a sulphoacid. The oxyacids are much the most numerous. The following graphic formulas show how O and S act as linking agents:—

Carbonic acid



$$\left.\begin{array}{l} H-O- \\ H-O- \\ O= \end{array}\right. C$$

Sulphocarbonic acid



$$\left.\begin{array}{l} H-S- \\ H-S- \\ S= \end{array}\right. C$$

Ternary acids may be regarded as hydrates of negative elements.

If the number of HO groups equals the valence of the — atom or atoms, we have an ortho-acid. Thus, $S^{VI}(HO)_6$ is orthosulphuric acid. Ortho-acids are unstable, tending to lose 1 or more molecules of water, leaving 1 atom of O for every 2 hydroxyl groups that break off H_2O. Thus, orthosulphuric acid, by losing 2 molecules of H_2O, becomes $S^{VI}O_2(HO)_2$, which is ordinary sulphuric acid, H_2SO_4. Acids derived from the ortho-acids in this way are known as meta-acids. The meta-acids are more stable than the ortho-acids, and are hence more frequently met with. The strongest acids are generally those in which the acidic (negative) element exerts a high polarity-value; thus, the valence of S is 6 in sulphuric acid.

The properties of acids in general are briefly as follows:—

1. Dilute solutions have a sour taste; example, vinegar.

2. In solution they change litmus and other vegetable colors from blue to red.

3. They corrode metals, with evolution of the H of the acid, the metal taking the place of the H, forming salts.

4. They neutralize bases, with the production of salts and water. The heat of neutralization signifies the amount of heat evolved when one gram-molecule of an acid and one gram-molecule of a base dissolved in water are mixed.

5. On living tissues they have either an astringent or a caustic effect, according to the strength of the acid or the degree of dilution.

The H of an acid which can be replaced by metals to form salts is termed the basic hydrogen (since it plays the + rôle), and in empiric formulas is generally written first, apart from the H of the compound radical, if such there be. By the basicity of an acid is meant the number of atoms of basic hydrogen. Thus, $HC_2H_3O_2$ is monobasic, $H_2C_2O_4$ is dibasic, and $H_3C_6H_5O_7$ is tribasic. The true radical (not salt residue) of an acid is obtained by subtracting as many OH groups as equals the basicity of the acid.

A base consists of a + element (metal) united to H by means of linking O. Otherwise stated, a base is a hydrate of a metal. It can be made by the action of a metal on water. Bases are nearly always ortho in character: *i.e.*, the number of HO groups equals the valence of the positive atom or atoms. Inorganic bases are commonly called hydrates or hydroxids. Strong bases are sometimes known as alkalies. The strongest bases are those in which the basic (positive) element is of a low polarity-value: *e.g.*, $K^I - O - H$.

The properties of bases are, in general, the opposite of those of acids:—

1. Dilute solutions have an "alkali" taste.

2. They restore the blue color of litmus and other vegetable products.

3. They corrode some of the less + metals, evolving H and forming salts.

4. They neutralize acids, producing salts and water.

5. On living tissues they exert a caustic effect, blistering and forming soap with the fats. Weaker solutions dissolve mucus and false membranes.

The number of replaceable H atoms in a base determines its so-called acidity. Thus, KHO is monacid; $Ba\,(HO)_2$ is diacid. The equivalent of an acid or base is the quantity thereof equal to one molecule divided by the basicity or acidity.

A salt consists of a — element joined to a + element, either directly or by means of linking O or S. Salts are formed in five ways:—

1. By the union of a + and a — element, as:—

$$Au + Cl_3 = AuCl_3.$$

2. By the union of a + oxid and a — oxid:—

$$CaO + CO_2 = CaCO_3$$

3. By the union of an acid and a base:—

$$HCl + KHO = KCl + H_2O$$

4. By the action of an acid or a base on a metal:—

$$Zn + H_2SO_4 = ZnSO_4 + H_2$$

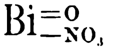
5. By substitution of one radical for another:—

$$AgNO_3 + NaCl = NaNO_3 + AgCl$$

This is by far the most frequent method of preparing salts.

When the basic H of an acid is all replaced by a metal, we have a neutral or normal (secondary) salt. $ZnSO_4$ is an example of a normal salt, in which 1 atom of the diad Zn has taken the place of the 2 atoms of H in H_2SO_4. If the acid is in excess and its basic H is only partially replaced by the + element, we have an acid, primary, or bi-salt (so called because the proportion of acid radical to metal is twice what it is in normal salts). Of this class, $NaHCO_3$ is an example, being derived from H_2CO_3 by the substitution of 1 atom of Na for 1 of the 2 of H.

When part of the basic H of an acid is replaced by one metal and part by another, we have what is called a double salt, of which $KNaSO_4$ is an example. Basic, oxysalts or subsalts are formed when the base is in excess of the acid with which it is combined, leaving part of the O or HO of the base undisturbed. They may be regarded as bases in which part or all of the H has been replaced by acid radicals. Hg salts show a marked tendency to become basic.



$$Bi{\genfrac{}{}{0pt}{}{=O}{-NO_3}}$$

is the most important basic salt, corresponding to the neutral or saturated salt $Bi(NO_3)_3$. Subsalts are generally unstable;

hence of uncertain composition. Persalts are ready oxidizers, and deflagrate on heating. Hyposalts are strong reducing agents.

When a metal or a base is acted upon by two acids at the same time, salts of both acids are formed, the relative amount of each varying with the quantity of each acid, and also with their relative affinity for the given metal. Thus, Na has twice as great affinity for HNO_3 as for H_2SO_4.

By the chemic reaction of a substance in the fluid form we mean the change of color produced in litmus-paper immersed in the liquid. If the change is from red to blue, the reaction is alkaline; if the reverse, acid. When either color becomes violet, the reaction is neutral. In a few instances—*e.g.*, cows' milk—the reaction is amphoteric, changing blue litmus to red and red to blue. This paradox is explained by the presence of different salts of an alkaline and of an acid reaction.

The terms neutral, acid, and basic as applied to the composition of the salt molecule do not necessarily signify a similar chemic reaction. A strong acid with a weak base will form salts, as a rule, all of acid reaction; for this reason the sulphates generally are acid in nature and hence astringent. Conversely, a weak acid and a strong base yield salts of alkaline reaction. The acid or bicarbonate of sodium, for instance, is used largely as an antacid on account of its alkaline reaction. The salts of the hydracids are usually neutral in composition and reaction.

For convenience of comparison, it is said that acids, bases, and salts are built upon the water (H — O — H) type. In the acid one of the H atoms is replaced by a — element, expressed thus: $\overset{-}{E} — O — H$. In the base a + element is substituted for the H atom; as, $\overset{+}{E} — O — H$. In the salt both H atoms are displaced, the one by a + element, the other by a — element, represented thus: $\overset{+}{E} — O — \overset{-}{E}$.

In organic chemistry we have three groups of compounds corresponding to acids, bases, and salts, and termed amids, amins, and alkalamids, respectively. In these N acts as the linking element instead of O or S. These compounds are said to be built upon the ammonia (H_3N) type. P and As also rarely act as linking agents.

According to the theory of electrolytic dissociation, now well established, dilute aqueous solutions of electrolytes contain no molecules, but only cations and anions. Thus, a weak solution of NaCl breaks up into the cation Na and the anion Cl; one of KBr into K and Br. Hence, a mixture of these solutions has the same properties as a mixture of solutions of similar strength of KCl and NaBr. Acids dissociate into an H cation and an anion varying with each acid, and the strength of any acid depends upon the number of H ions present. Bases dissociate into (HO) anions and various metals. The H and the

HO ions cannot exist independently in the same solution, but unite and neutralize each other to form H_2O, the other ions remaining unchanged. Strong acids or bases are highly ionized; weak ones, slightly so.

The ion of H is called hydrion, and the names of other metals end in *ion*. The HO ion is hydrox*idion;* Cl, chloridion; and so on for other anions. When the name of a salt ends in *ate*, the corresponding ion has the suffix *anion;* the ending for an *ite* ion is *osion*—thus, ClO is hypochlorosion. A round dot is sometimes used to indicate a cation; and an accent mark or prime, an anion, valence being shown by the number of dots or primes.

The strength of an acid is proportional to its degree of dissociation—HCl more than H_2SO_4. In concentrated solution H_2SO_4 breaks up into $H^\cdot$ and HSO'_4 (monosulfanion); when more diluted, into $2H^\cdot$ and SO''_4 (disulfanion). Weak acids give off one $H^\cdot$ (and HCO'_3 in case of carbonic); there is little or no $H^\cdot$ in solutions of their acid salts, hence they are neutral or alkaline. In the electrolysis of an oxacid the group first separated at the + electrode is called the residue of the acid.

The anion in the case of oxygen salts usually breaks up, with evolution of O. Sulphates on electrolysis liberate SO''_4 (at the + pole), which reacts with H_2O to form H_2SO_4 and set free O. Precipitates of salts by reaction are no longer ionized but molecular. The salts of weak bases or weak acids break up by hydrolysis, on dissolving, into the corresponding free acid and free base, each giving its own reaction, with gradual changes of tints in presence of an indicator.

The amount of electricity carried by a univalent gram-ion (weight of ion in grams) is 96,580 coulombs, and is termed the unit charge. Divalent ions carry twice and trivalent ions three times as much. This explains Faraday's law of electrolysis, viz., when a current is passed through solutions of salts of different metals, the amounts of these set free at the electrodes are proportional to their atomic weights divided by the valence.

The solubility of a salt (or element) is influenced by the presence of an electrolyte with a common ion, causing primary supersaturation by concentration of ions. Mendelejeff held that a solution is a "homogeneous liquid system of unstable dissociating compounds of the solvent with the substance dissolved."

The chemic energies of molecules come forth as they are broken up into ions. Most, if not all, chemic reactions are ionic in character, and some of the biologic effects of acids and bases have been proved to depend solely upon the H ions of the acid and the HO ions of the base. Acids tend to decrease the secretions of acid glands and increase alkaline secretions, while alkalies have just the opposite effects. All forms of activity in the body are accompanied by electric discharges, which are possible only in the presence of ions (mineral salts).

CHEMIC REACTIONS AND EQUATIONS.

By chemic reaction is understood the mutual action on each other of the factors in a chemic change. A substance added to another to produce such a change is called a reagent.

Experiment.—Add $BaCl_2$ to $MgSO_4$ and note turbidity.

In this reaction $BaCl_2$ is the reagent used as a test for sulphates; the factors in the reaction are $BaCl_2$ and $MgSO_4$; the products of the reaction are $BaSO_4$ and $MgCl_2$.

The burning of coal or wood is another example of chemic reaction, in which the factors are the O of the air and the C and H of the fuel, the products being H_2O and CO_2.

The heat evolved in ordinary reactions of combination is absorbed in reactions of decomposition. If in a chemic reaction stronger affinities are satisfied than are broken, energy will be liberated; if, on the other hand, stronger affinities are broken than are satisfied, energy will be required to bring about the reaction. A combination of atoms into molecules leads to liberation of energy, while the separation of a molecule into its atomic elements requires energy. In exothermic (+) reactions heat is generated; in endothermic (—), absorbed from surrounding bodies (cooled). Compounds (N_2O, H_2O_2, HI) are formed endothermically with difficulty, and are unstable, decomposing with evolution of heat (nitrates, chlorates).

The heat of formation of a compound is the positive or negative heat effect attending the formation of one mol of a compound from its elements; that of water is 68,400 calories. The heat of reaction is the sum of heats of formation of substances produced minus sum of heats of formation of substances reacting.

Chemic reaction is favored by everything that aids a free mixture of the molecules of the factor substances: that is, by heat, light, electricity, fusion, solution, volatilization, and pulverization. A rise of 10° about doubles the velocity of a reaction. Thus, a reaction which at 0° requires 24 hours for completion would be finished in 84 seconds at 100°. Colloids are feeble in all their chemic relations. Solids may be made to combine with each other by great pressure.

Chemic action is limited to definite weights and is proportional to the active mass of each substance taking part in the change—the law of mass-action. For example, red-hot iron in excess decomposes water (steam), taking up oxygen (forming Fe_3O_4), and setting free hydrogen; while an excess of hydrogen, as in the oxyhydrogen blowpipe flame, takes away the oxygen from the oxids of iron, forming water and leaving reduced or metallic iron. H_2CO_3 decomposes alum bases and silicates in solution, but is displaced by them on fusion.

Some reactions proceed only to a certain limit. Thus the decomposition of $CaCO_3$ ceases when CO_2 has collected up to a certain pressure. In other instances, the majority, there are two opposite reactions, which mutually lessen the products. For example, when ethyl alcohol is treated with acetic acid, forming ethyl acetate and water, the change ceases when two-thirds of the material is transformed, since the water and the ethyl acetate react upon each other to produce the reverse change. This limiting of reaction is most noticeable in changes accompanied by high temperatures, as in combustion or explosion. Optically active substances, reversed to their mirror-like isomers (as dextro- to levo-tartaric acid), develop no heat whatever, and so yield equal proportions of an inactive mixture of opposite salts.

Common salt can be completely decomposed by excess of HNO_3; and niter, by excess of HCl. The reaction between H_2SO_4 and NaCl is carried to the end, because the resulting HCl is volatile and passes away, and H_2SO_4 is non-volatile. Dynamic, not static, equilibrium is attained in reversible reactions. Heterogeneous equilibrium obtains with immiscible liquids and solids. The two or more parts (separated by bounding surfaces) are called phases of the system. The number of degrees of freedom diminishes with increase of number of phases present, and increases with number of components. Phase Rule of Gibbs: P (phases) $+$ F (freedom) $= C + 2 - P$. When a change of condition, as in the various forms of H_2O, can take place in either direction, we have what is termed a reversible cycle.

The reagent for a given substance or class of substances is, of course, a test for that substance or class, as well as an antidote in the case of poisons. Thus, $BaCl_2$ is the test-reagent for sulphates in general, as it forms with them the insoluble sulphate of barium; $AgNO_3$ is the test-reagent for chlorids; and, conversely, common salt (NaCl) is the chemic antidote for poisoning by $AgNO_3$.

Experiment.—Show ppt. of $AgNO_3$ with NaCl.

A precipitate (ppt.) is a substance thrown out of solution. In the above example AgCl is the ppt. In manufacturing chemistry precipitation is a common method of preparing drugs. The ppts. produced by hot, strong solutions are generally denser, coarser, and heavier and more often crystalline than those produced in cold, dilute solutions.

A chemic equation is the statement, by means of formulas and of $+$ and $=$ signs, of the equality between the sum of the factors and the sum of the products of a chemic reaction. The equation represents the reaction between molecules, and consequently between the homogeneous substances which the molecules constitute. It also shows the numeric balance of molecular weights, thus:—

$$137 + 71 + 24 + 32 + 64 = 137 + 32 + 64 + 24 + 71$$
$$BaCl_2 + MgSO_4 = BaSO_4 + MgCl_2$$

There are a few simple rules in regard to the writing of chemic equations:—

1. Positives combine with negatives, and negatives with positives.
2. Only whole molecules are represented.
3. The valence of atoms and radicals must be fully satisfied.
4. It is customary to indicate the ppt. (if any) by underlining its formula.

Chemic equations are used to represent three general kinds of reaction:—

1. Simple union of elements or compounds:—

$$H_2 + Cl_2 = 2HCl$$
$$CaO + CO_2 = CaCO_3$$

2. Decomposition of a complex molecule into simpler ones:—

$$CaCO_3 = CaO + CO_2$$

3. Mutual reaction between two or more molecules (double decomposition), with interchange (metathesis) of atoms or radicals:—

$$2KI + HgCl_2 = HgI_2 + 2KCl$$

This class is by far the most common.

In chemic reactions of combination there is contraction; of decomposition, expansion. In reactions of substitution or double decomposition, the volume in a gaseous state remains constant. The law of Avogadro was further established by Gerhardt, showing that gases combine in equal volumes, or that the reaction of equal volumes of gases precedes all others. The action between reacting substances is equivalent to the product of their masses.

STOECHIOMETRY.

Since the molecular weight of any compound denotes a definite amount, it is easy to compute, by simple proportion, the exact percentage of any of the component elements. Again, in a similar manner, we can readily determine from the weight given of any of the members of an equation the weight required of any other member. The proportion should be first stated with formulas. Thus, let it be required to find how much zinc oxid can be obtained from 100 gm. of zinc:—

$$Zn : ZnO :: 100 : x$$
$$65 : 81 :: 100 : x$$

Answer is 124⁸⁄₁₃ gm.

Such calculations are of immense importance in manufacturing chemistry. The branch of the science that they constitute is known as stoechiometry. The unit of weight for gases is the crith (0.0899 gm.), the weight of a liter of H in a vacuum at 0° and 760 mm. pressure. Of any normal gas, 11.2 liters weigh as many grams as is equal to the combining weight.

MENDELEJEFF'S TABLE.

SERIES.	GROUP I. R_2O	GROUP II. RO	GROUP III. R_2O_3	GROUP IV. RO_2	GROUP V. R_2O_5	GROUP VI. RO_3	GROUP VII. R_2O_7	GROUP VIII. RO_4
1	H=1							
2	Li=7	Be=9	B=11	C=12	N=14	O=16	F=19	Ne=20
3	Na=23	Mg=24	Al=27	Si=28	P=31	S 32	Cl=35.4	A=39.6
4	K=39	Ca=40	Sc=44	Ti=48	V=51	Cr=52	Mn=55	Fe, Co, Ni
5	Cu=63	Zn=65	Ga=70	Ge=72	As=75	Se=79	Br=80	Kr=81.2
6	Rb=85	Sr=87	Yt=89	Zr=90	Cb=94	Mo=96		Ru, Rh, Pd
7	Ag=108	Cd=112	In=113	Sn=118	Sb=120	Te=125	I=127	Xe=128
8	Cs=133	Ba=137	La=139	Ce=140	Di=142	Tb=160		
9			Er=166					
10			Yb=173		Ta=182	W=184		Os, Ir, Pt
11	Au=197	Hg=200	Tl=204	Pb=207	Bi=208			
12				Th=232		U=239		

NOTE.—The symbol R stands for any monad element, or radical, and the general formula shows the highest valence of the members of each group, with some exceptions. Thus, we may form oxids as follows: Li_2O, CaO, Al_2O_3, CO_2, N_2O_5, SO_3, Cl_2O_7, and OsO_4.

THE PERIODIC LAW.

The most satisfactory classification of the elements is that of Mendelejeff, which is based upon the atomic weights. He observed that the first seven elements after H were representative of as many groups of similar elements. Each of these is put at the head of a vertic column, inclosing the elements which it resembles. The lateral rows, or series, or small periods, two of which make a large period, run in the orders of the atomic weights, with a few breaks here and there. It will be noted that alternate numbers of the same group resemble each other more than do adjacent numbers. With the aid of this table its author predicted the properties of Ga, Ge, and Sc while these elements were still undiscovered. Doubtless the other vacant places will be filled in time. Group VIII is made to include a number of intermediate elements which may later be arranged in a set of groups.

QUESTIONS ON THEORETIC CHEMISTRY.

1. Name and give symbols of ten elements whose names begin with C.

2. Name five elements which have both an English and a Latin name.

3. Name a liquid element.

4. Peroxid of hydrogen gives off atomic O. Is this more or less active than the atmospheric O?

5. Why does NaCl dialyze more readily than $C_{36}H_{60}O_{30}$?

6. What is the density of As in the gaseous state?

7. Why is density always one-half the molecular weight?

8. Calculate from the table the molecular weight of H_2SO_4, avoiding fractions and using the nearest whole numbers.

9. What is the most important distinction between metals and metalloids?

10. Which is likely to be more stable: a compound of O and N or one of O and As?

11. What element is the unit of valence, atomic and molecular weight, and density?

12. Why does O enter into more chemic combinations than any other element?

13. Name a monad, a diad, a triad, a tetrad, a pentad, a hexad, a heptad, and an octad.

14. What element has the highest atomic weight, and how much is it?

15. Why should we expect P rather than Hg to show allotropic tendencies?

16. Why do elements combine in simple proportions?

17. Give reasons for the law of even numbers.

18. Write formulas of potassium iodid, calcium oxid, mercuric chlorid, carbon dioxid, and sulphur trioxid.

19. What is the valence of the radical SiO_4, and why?

20. Write formula of ferric ferrocyanid; of ferrous ferricyanid.

21. Write graphic formulas of some acid, base, and salt.

22. Name: $Fe_4(P_2O_7)_3$; $(BiO)NO_3$; $Na_2B_4O_7$; $HC_7H_5O_3$.

23. Write graphic formulas of ferric chlorid, mercurous iodid, and manganic sulphate.

24. Translate "protiodid of mercury, sesquichlorid of iron, and tersulphate of iron" into modern chemic nomenclature.

25. Name and give basic formula of a monobasic, dibasic, tribasic, and tetrabasic acid.

26. Name a diacid base.

27. What two elements are present both in bases and in oxyacids, and in what way as regards composition do these two classes differ?

28. What substance is always formed when an acid and a base are brought together?

29. Mention and give formulas of five salts, each formed in a different way.

30. Name an acid salt which is alkaline in reaction.

31. Write equation for reaction between $CaSO_4$ and Na_2CO_3.

32. Find percentage by weight of O in H_2O.

33. Find percentage by weight of Ca in $CaCO_3$.

34. What percentage by weight of CO_2 gas is given off on burning limestone ($CaCO_3$)?

35. How much $AgNO_3$ can be made from 108 grams of silver?

36. How much NaCl is required to make 500 gm. of HCl? ($2NaCl + H_2SO_4 = 2HCl + Na_2SO_4$.)

37. What is the volume of a kg. of H at standard temperature and pressure?

38. Calculate the percentage composition of potassium nitrate.

39. What is the weight of a liter of O?

40. What weight of NaHO is required to neutralize a mg. of HCl?

41. Write equation for reaction between $NaNO_3$ and H_2SO_4.

42. Write equation for reaction between $NaHSO_4$ and large excess of HNO_3.

43. How do acids and bases neutralize each other?

44. How many electrons should the atom of radium comprise?

45. Why does steam saturated with limewater break down false membranes when inhaled?

46. In the electrolysis of CuO, how many times as much Cu as of O, by weight, are set free?

47. If the skeleton of a man weighs 24 pounds, and contains 58 per cent. of $Ca_3(PO_4)_2$, how much P is present?

48. Give formula for chlorosion, nitranion, hydroxidion, hydrion.

49. How does adding HCl to a saturated solution of NaCl ppt. some of the latter salt?

INORGANIC CHEMISTRY.

METALS.

THESE are solid substances (except mercury and hydrogen), electropositive, and good conductors of heat and electricity. Their oxids form bases with H_2O.

DISCOVERY AND DERIVATION.

Au, Ag, Hg, Sn, Cu, Zn, Pb, and Fe were known to the ancients. The corresponding Latin names from which the symbols were derived are aurum (color of fire), argentum (white), hydrargyrum (liquid silver), stannum (stone), cuprum (island of Cyprus), zincum (German, *zinn* or tin), plumbum (heavy), and ferrum. Antimony (from *anti* and *moine*, because some monks were poisoned with it; stibi is the Greek name for native sulphid) and bismuth (German *wismuth*, meaning variegated tints) were discovered in the latter part of the fifteenth century. Arsenic (male or strong) was discovered by Schröder in 1694; cobalt (mine-demon) by Brandt in 1733; platinum (little silver) by Wood in 1741; nickel (worthless) by Cronstadt in 1751; manganese (confounded with Mg) by Galm in 1774; molybdenum (Greek for lead) by Hjelm in 1782; and chromium (color) by Vanquelin in 1797. Humphry Davy in 1807 and 1808 first separated K, Na, Ca, Ba, Sr, and Mg from their oxids. The first element is so called from potash, and its symbol is derived from *kali*, the Arabic word for ashes. Sodium refers to soda-ash; natrium to *natron*, the old name for natural deposits of Na_2CO_3. *Calx* is the Latin name for lime, or CaO. Barium is of Greek origin, and means heavy. Strontium is named after the Scottish village Strontian, where $SrCO_3$ was first found. Magnesium derives its name from Magnesia in Asia Minor. Cadmium (from calamine) was isolated by Stromeyer in 1817; lithium (stone) by Arfvedsen in 1817; and aluminum (from alum) by Wöhler in 1828.

Many metals have been named after persons, places, and deities: for example, cerium after the goddess Ceres; columbium or niobium after Columbia and Niobe; gadolinium after John Gadolin; gallium from Gaul; germanium from Germany; masrium from the Arabic name of Egypt; palladium after Pallas; ruthenium from the Latin name of Russia; scandium after Scandinavia; polonium after Poland; tantalum after Tantalus; terbium, ytterbium, and yttrium after Ytterby in Sweden;

thorium after Thor; thulium after Thule; titanium after the Titans; uranium after the planet Uranus; and vanadium after the Scandinavian goddess Vanadis (Freya). Some are named after the color-lines seen in the spectroscope, as cesium, bright blue; indium, indigo; rubidium, red; thallium, green. Others take their names from some physic properties of the metal or its salts: *e.g.*, glucinum, sweet; iridium, rainbow; rhodium, rosy; lanthanum, unseen; osmium, odor; samarium, samarskite; tellurium, earth; tungsten, from the Swedish, meaning weighty stone; wolfram, meaning wolf-cream; and zirconium, jargon. Ammonium was so called after Jupiter Ammon, near whose temple in Libya the Arabs of the desert long ago made NH_4Cl by distilling camels' dung as a substitute for common salt. Praseodymium (garlic) and neodymium (new) are derived from didymium (double), which was formerly believed to be an element, but is really a mixture of the two metals first mentioned. Radium shines of itself, hence the name. It was discovered in 1898 by Mme. Curie.

ORDINARY SOURCES OF METALS IN NATURE.

Free State	Gold: river-beds and rock veins; always free except as tellurid; always contains Ag.
	Platinum and Pd, Rh, Ir, Ru, and Os: river-beds. Ir often with Au.
	Bismuth: also as oxid and sulphid.
	Silver: also as sulphid, chlorid, and tellurid, and as silver amalgam.
	Mercury: minute, disseminated globules, with sulphid.
	Copper: cubes and octahedra; usually oxids, sulphates, and carbonates; also found in hulls of various grains.
	Arsenic: rarely free in lamellar, kidney-shaped masses.
	Fe: rarely free but impure in meteorites, lavas and basalt.

COMBINATION.

Light Metals.—Sp. gr. below 4.

The Alkali Metals.—On account of the ready solubility of their salts, they are not found to a great extent as ores, and never occur in a free state. K is obtained as carbonate from the ashes of land-plants (sugar-cane, beet-root, marc, etc.); also from the double chlorid of K and Mg (carnallite), which is extensively mined at Stassfurt, Germany. K compounds, especially the carbonate, constitute, by weight, about one-third of sheep's wool, and are essential ingredients of all the formed elements of the human body. Na is very abundant as the chlorid and the sulphate in all soils and natural waters and in atmospheric dust. The silicate of Na is present in the tissues of plants; the chlorid, phosphate, and carbonate are very necessary ingredients of the blood and its secretions. Li salts are comparatively rare. They are found in mineral springs and are also obtained from the ashes of the beet and tobacco. NH_3 is present in decaying nitrogenous matter generally: *e.g.*, in barn-yard manure. The chief commercial sources of NH_4 compounds are the guano-beds of South America and the ammoniacal liquors obtained as a by-product from coke-, iron-, and gas-works. Cs and Rb are both very rare metals and of no present practical importance.

Alkaline Earths and Mg.—These occur chiefly as sulphates, carbonates, and silicates. Next to Al, Ca is the most abundant terrestrial metal, being present in all soils and natural waters, and hence in the tissues and juices of plants and animals. Sr is found in small amounts in sea-water and sea-plants (*Fucus vesiculosus*) and in certain mineral springs, as well as in ores. Ba is found only in combination, and may be obtained in small quantities from the ashes of sea-plants and of some trees, particularly the beech. The metal Mg is never found free. In combination it is widely distributed, usually with Ca. Mg salts are present in plants in considerable quantities.

Aluminum.—This metal, though never found free, is the most widely distributed in the earth's crust, making, as it does, —in the form of silicates, oxids, hydrates, and fluorids,—the great mass of common rocks, which in their natural decomposition turn into clay. Every brick has nearly a pound of Al in it. Ga, In and Sc belong to the aluminum group.

Heavy Metals.—Sp. gr. above 4.

Sulphids Chiefly.—As, Sb, Co, Ni, Cd, Mo, Hg, Pb, and Cu.

Oxids Chiefly.—Sn, Mn, and Cr.

Sulphid and Chlorid.—Ag.

Sulphids, Oxids, and Carbonates.—Fe and Zn.

Meteoric Rocks.—Fe and Ni.

Common Associations.—Co and Ni; Fe and Mn; Cd and Zn; Ag and Pb; Ca and Mg. Co and Ni are obtained almost entirely from mines in Ontario and New Caledonia.

The color of ordinary rocks and soils (from decomposition of silicate to oxid) is due to iron as is the color of blood and green plants. Fe is next in abundance to Ca. Cu is widely distributed in nature, there being traces in plants and animals; a person takes in daily about 1 mg.

Uranium and the radioactive metals, radium, actinium and polonium, are obtained from pitchblende, ten tons of the latter yielding about one gram of Ra. This metal is always present in minerals containing U or Th.

EXTRACTION OF METALS.

Electrolysis.—From fused chlorids usually; Al (from bauxite); alkali metals and alkaline earths; Mg (from carnallite). In the Hall method of extracting Al by electrolysis, iron boxes lined with carbon (cathode) are used, along with carbon cylinders (anode), in connection with a solvent bath of melted fluorids of Al, Na and Ca, the heat generated by the electric current being sufficient to maintain fusion. Alumina is added from time to time as resistance is shown to increase by means of incandescent lamps. Pure Cu, crystal Au, and other metals are obtained by electrolysis by suspending plates of the same metals in solutions of their salts.

Decomposition with metallic Na or K; weaker metals driven from their combinations; Mg, Al, Ca, Ba, Sr, U. Powdered Al is used in the reduction of metals having a high fusing-point.

Roasting, usually with sulphids or oxids, and reduction with charcoal, lime, or iron slag.

Lead.—$PbS + 2PbO = 3Pb + SO_2$. $PbS + PbSO_4 = 2Pb + 2SO_2$.

Another method is to roast the ore to form oxid, then combine with silica, and reduce this silicate in a blast furnace with reduced iron-ore.

Mercury.—$HgS + O_2 = Hg + SO_2$. Iron is sometimes added. Collect under H_2O, strain through linen or chamois and distill. It is better purified by shaking with dilute H_2SO_4 containing a few drops of solution of $K_2Cr_2O_7$, causing oxidation and solution of contaminating metals.

Copper.—$2Cu_2O + Cu_2S = 3Cu_2 + SO_2$. Ore is fused with a siliceous flux, sometimes containing CaF_2. The resulting "blister copper" contains some Cu_2O, which is removed by fusing with coal and stirring, or by electrolysis. Fe immersed in a solution of $CuSO_4$ yields Cu and $FeSO_4$—a reaction of substitution.

Zinc.—Charcoal reduction and distillation.

Cadmium.—Can be separated by means of Zn in dendritic form from acid solutions.

Antimony.—Charcoal reduction or by heating with half its weight of Fe.

Arsenic.—Charcoal reduction.

Manganese.—From carbonate or oxid.

Chromium.—From oxids with charcoal.

Tin.—From oxids.

Nickel.—Resulting "speiss" is dissolved in HCl, pptd. with $H_2C_2O_4$, and reduced with lime and carbon.

Cobalt.—Same as for Ni.

Bismuth.—Fused (after roasting) with slag, iron, and charcoal. Melted mass settles in two layers; the lower contains Bi.

Alkali Metals.—Old method = charcoal reduction of carbonate, distilling metal and passing through naphtha.

Fractional Distillation.—*Cadmium.*—Separated from zinc.

Zinc.—Oxid or carbonate reduced with charcoal in iron retorts, and liberated metal distilled over.

Mercury.—When cinnabar is heated with lime the metal Hg volatilizes. It can be refined by redistillation (Zn and Bi also pass over), and on a small scale by pouring the dirty metal through a filter-paper having a small pin-prick at the bottom—after shaking with fine sugar in a bottle, blowing in air several times with a bellows.

Magnesium.—Purified and rendered homogeneous by distilling.

Sublimation.—Arsenic from mispickel or white arsenic.

Reduction of heated ore with H: Much employed in laboratory, but not on a large scale. Reduced iron is obtained this way.

$$Fe_2O_3 + 3H_2 = 3H_2O + Fe_2$$

The most modern and powerful method of reduction (electric furnaces) consists in using the intense heat of a current of electricity from a dynamo through a conductor of great resistance in the presence of carbon. Al is now produced from corundum in this way. The best quality of iron is prepared in the electric furnace. Some refractory metals are extracted in a very pure state by distillation in the electric furnace, condensing upon a tube of running water which passes through the furnace.

Special Methods.—*Silver.*—The mode of separating Ag from its ores varies with the particular combination. There are five main processes employed. 1. The electrolytic method is applied to ores alloyed with Cu or CuO. 2. In the amalgamation process, as practiced in the United States (Washoe process), the silver ore is ground with Hg, common salt, and $CuSO_4$ (and sometimes 2 per cent. Na to prevent "flouring or sickening" of the Hg). After straining the Ag amalgam, the quicksilver is separated by distillation, leaving a residue of Ag. 3. Wet extraction is accomplished by roasting ores containing AgS, Cu, and Fe at such a temperature as to form the oxids of Cu and Fe and the sulphate of Ag. The latter salt is separated from the insoluble oxids by lixiviation with H_2O, and is then pptd. with metallic Cu. Or common salt is added to the ore before roasting, forming AgCl, which is dissolved out from the other matters with $Na_2S_2O_3$, pptd. with Na_2S as a sulphid, and finally reduced by intense heat and a current of air. 4. The cupellation process is probably the most ancient. It is applied to argentiferous lead ores, which are roasted in a reverberatory or blast furnace. The lead is largely oxidized and skimmed off. When Pb is in great excess, as is generally the case, it must first be partly removed by melting (Pb fuses at 326°, Ag at 954°) and fractional crystallization on cooling (Pattinson's process); or by alloying the melted ore with 18 parts Zn to 1 of Ag, then oxidizing the Zn and washing the oxid away with H_2O. 5. The rather recent cyanid process depends on the solubility of Ag in the alkaline cyanids. Ag, obtained by any of these methods, is rendered chemically pure by dissolving in HNO_3, pptg. with HCl, and reducing the resulting chlorid with Na_2CO_3, in a crucible coated with a hot saturated solution of borax.

The fire assay for silver depends upon the fact that any compound of Ag will, in the presence of PbO, be converted into metallic Ag and the corresponding Pb compound (more volatile than that of Ag). The "test lead" used in scorification is in the form of fine shot. The resulting buttons must be cupelled to separate Pb from Au and Ag.

Commercial Ag usually contains Cu. Gold can be separated from silver by passing Cl gas through the molten alloy until orange-colored fumes begin to rise. AgCl is reduced by placing between two iron plates and immersing in water acidulated with H_2SO_4 for a few hours.

Ag is not completely parted from Au unless the proportion of these is 3 to 1, respectively. The button to be parted should be hammered flat, put in a parting flask, then covered with HNO_3, sp. gr. 1.20 (equal volumes water and concentrated acid). The flask is heated until brown fumes cease to appear. The liquid is poured off and the button covered with HNO_3 and boiled again. The residue of Au will be in powder form if the Ag was in excess of threefold the gold.

Iron.—This metal is extracted from oxids and carbonates by reducing with alternate layers of coal and limestone in a double, conic, fire-clay blast furnace. The limestone combines with the silica of the ore to form a fusible glass (cinder or slag). CO_2 is produced at the bottom of the furnace, while the CO formed in the body of the furnace acts as a reducing agent. The resulting molten Fe takes up some C as it sinks to the bottom, where it is run off into molds as cast- or pig-iron. It contains 3 to 6 per cent. C, a little Si, and traces of S, P, and Mn. Wrought Fe is nearly the pure metal, containing less than ½ of 1 per cent. C. It is made from cast Fe by a process of thorough oxidation termed puddling, conducted in a blast furnace with constant stirring.

Wrought iron is rendered weak and brittle when cold ("cold short") by P—when hot ("red short") by S. Steel contains from 0.8 to 1.5 per cent. C. It is made nowadays chiefly by the Bessemer process, consisting essentially of the addition to molten wrought Fe of a certain proportion of spiegeleisen, or ferromanganese, which is a mixture of white cast Fe with about 7 per cent. Mn. The Bessemer converter is egg-shaped and is made of wrought iron lined with gannister (a siliceous rock). The open-hearth process is similar, except that it is performed on the hearths of reverberatory furnaces. The requisite amount of C is obtained by adding ferromanganese or by filtering over carbon filters. Cement or crucible steel is made by carbonizing in furnaces wrought Fe packed in charcoal and siliceous material. The resulting "blister steel" is melted in crucibles and cast in small ingots. Harveyized steel, employed for armor plate, is prepared by heating steel to the f.p. of cast iron, then tightly packing with carbon until it has taken up about 1 per cent. of this, then cooling in water. Steel is readily distinguished from iron by the dark stain (carbon) brought out on the former by a drop of HNO_3.

Gold.—There are four main processes of extraction: 1. Placer mining (panning, cradling, hydraulic mining), in which the Au is separated from sand and earth by washing through troughs which contain Hg in hollows or on Cu plates to catch the gold in its downward passage. The Au and Hg are parted by distilling in a retort. 2. Stamping quartz to a fine powder and then washing away the lighter earthy matter. 3. The Cl process for pyritic ores, which comprises the following steps: Roasting, mixing with H_2O, and saturating with Cl for twelve hours to form $AuCl_3$, which is pptd. from solution by adding oxalic acid or $FeSO_4$, as a fine brown powder (spongy or crystalline gold). Shredded gold is made by slightly heating an acid solution of $AuCl_3$, adding an aqueous solution of sugar or gum arabic, and removing the web-like masses quickly with a glass dipper. 4. The cyanid process depends on the solubility of the metal Au in solutions of the alkaline cyanids. $4Au + 8KCN + O_2 + 2H_2O = 4KAu(CN)_2 + 4KOH$. From this solution the gold is pptd. with zinc: $2KAu(CN)_2 + Zn = 2KCN, Zn(CN)_2 + 2Au$.

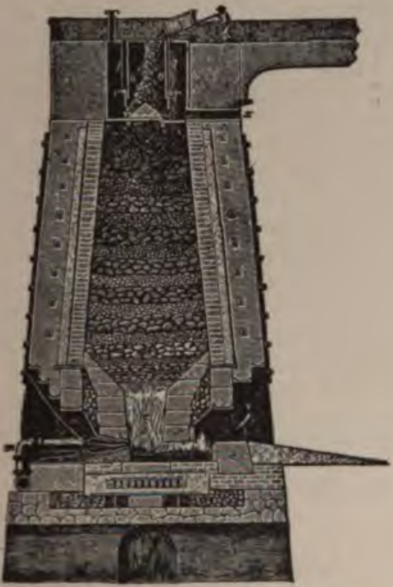


Fig. 22.—Sectional View of Blast Furnace.

Au is separated from Ag by electrolysis or by dissolving out the latter with HNO_3 or H_2SO_4. If necessary, before "parting," enough Ag must be added to make about 3 to 1 of Au: a procedure known as quartation. Cu is separated with H_2SO_4.

H_2SO_3 ppts. gold in scales. Gold is purified (as from Ir) by dissolving in nitrohydrochloric acid and precipitating with $FeCl_2$. The corrugated non-cohesive Au used by dentists is said to be prepared by tightly packing sheets of Au between leaves of unsized paper in Fe boxes, and then heating sufficiently high to carbonize the paper.

Platinum.—Deville's method of extraction consists in melting the ore with an equal weight of PbS and half as much Pb, which take away the Pt from the other metals. This alloy is then fused with access of air; the Pb is oxidized and flows off as a slag, leaving Pt as a spongy mass. This is now melted in a lime-furnace by means of the oxyhydrogen-blast lamp, and poured into molds. Pt black is prepared by dissolving the metal in aqua regia, evaporating excess of acid, then boiling with a strong solution of KHO and adding grape-sugar. Spongy Pt is prepared by heating the yellow crystalline ppt. obtained by adding NH_4Cl to Pt solutions.

Ammonium.—Free NH_4 can be prepared by heating Na in a sealed tube with NH_3 and then heating this product with NH_4Cl in another sealed tube. NaCl is formed, and also a dark-blue lustrous liquid, which soon decomposes into H and NH_3.

Granulated Metals.—Zinc and other granulated metals are prepared simply by melting and pouring into H_2O. Zn becomes brittle when melted several times, owing to formation of ZnO and contamination with the Fe of the ladle. It can be purified by throwing on the molten metal some dry NH_4Cl. Thick and earthy Zn or Pb can also be deoxidized with beeswax.

PHYSIC PROPERTIES OF METALS.

All are solid at ordinary temperatures, except NH_4 and Hg, which solidifies at — 39.4° and boils at 357¼°. It is volatile above 5°. H is sometimes considered a gaseous metal. Metals are electro-positive and opaque, except in very thin sheets. Nearly all are sectile: *i.e.*, can be cut without crumbling. Metals occurring free in Nature are generally crystalline, and all probably can be made to crystallize, cubes and octahedra being the prevailing types. Nearly all metals can be deposited from their solutions in pure crystals by a weak electric current.

When unoxidized, they present a shining appearance, called metallic luster, and are capable of being polished. When broken, the surface of steel shows a granular fracture; wrought iron, fibrous; Cu, silky; grain-tin, columnar; As, conchoidal; Zn, Sb or Bi, crystalline. To obtain the dull finish of Al, it is immersed in soda lye, then washed and placed in dilute HNO_3.

Experiment.—Procure a deposit of crystals of Ag by immersing a strip of Cu in $AgNO_3$ solution.

Nearly all metals are more or less white in color, often with

PHYSIC PROPERTIES OF METALS.

NAME.	STRUCTURE.	APPEARANCE.	SP. GR.	RELATIVE HARDNESS.[1]	FUSING-POINT (C.).	LINEAR EXPANSION.[2]	TENACITY RANK.	MALLEABILITY RANK.	DUCTILITY RANK.	HEAT CONDUCTION.[3]	ELECTRIC CONDUCTION.[4]	SPECIFIC HEAT.
Aluminum	Octahedra	Brilliant, blue-white	2.5-2.67	1.5	700°	$\frac{1}{432}$	8th	3d	8th	31.3	65.5	0.2143
Antimony	Obtuse rhombohedra	Bluish white	6.7	1.8	432°	$\frac{1}{923}$	Brittle	Brittle	Brittle	4	3.6	0.0508
Arsenic	Amorphous or crystals	Black or steel-gray	4.71-5.72	....	Volatile	....	Brittle					
Barium	Porous mass	Yellowish white	3.75	....	475°	....	Tough	Malleable	Ductile			
Bismuth	Lamellar crystals	Gray-white, rosy tinge	9.76	1.6	268°	$\frac{1}{717}$	Very brittle	Very brittle	Very brittle	1.8	1.4	0.0308
Cadmium	Octahedra	Lustrous white	8.66	1.4	320°	$\frac{1}{326}$	10th	8th	7th	20.1	24.4	0.0567
Calcium	Powder	Pale yellow	1.6-1.8	Like Au	Burns	....	Tough	Malleable	Very ductile			
Cerium	Like iron	Like iron	6.72	....	Below Ag							
Chromium	Crystalline powder	Light gray	5.9-7.3	Very hard	Above Pt							
Cobalt	Granular fracture	White, with red tinge	8.9	Very hard	1500°	....	1st	Like Fe	Like Fe	....	....	0.1070
Copper	Octahedra	Brilliant reddish	8.95	2.4	1054°	$\frac{1}{581}$	4th	5th	6th	85.5	97.8	0.0952
Gold	Octahedra or tetrahedra	Lustrous yellow	19.26-19.31	1.7	1067°	$\frac{1}{682}$	7th	1st	1st	53.2	76.7	0.0324
Iridium	Cubes and octahedra	Silver-white	22.4	Above Pt	Above Pt	....	Brittle					
Iron	Cubic crystals	Silver-gray	7.79-7.84	2.4	1275°-1375°	$\frac{1}{901}$ (cast)	3d	10th	4th	11.9	14.6	0.1123
Lead	Regular octahedra	Bluish gray	11.38	1.0	326°	$\frac{1}{351}$	12th	7th	11th	8.5	8.4	0.0314
Lithium	Waxy	Silver-white	0.59	....	180°							
Magnesium	Ribbons in commerce	Silver-white	1.75	Hard	Ignites	....	Very tenac'us	....	Very ductile			
Manganese	Like cast-iron	Gray-white	7.2	Very hard	White heat	....	....	Brittle				
Mercury	Liquid	Silver-white	13.55	....	−39°	....	....	....	....	13.5	1.8	0.0333
Nickel	Granular	Lustrous white	8.9	2.5	1450°	$\frac{1}{787}$	2d	11th	5th	Like Fe	12.9	0.1086
Platinum	Cubes and octahedra	Tin-white	21.5	2.0	1775°	$\frac{1}{1131}$	5th	6th	3d	8.4	14.5	0.0311
Potassium	Octahedra	Silver-white	0.865	Waxy	Ignites	....	....	....	....	....	....	0.1696
Silver	Regular crystals	Pure white	10.55	1.8	954°	$\frac{1}{524}$	6th	2d	2d	100	100	0.0570
Sodium	Octahedra	Silver-white	0.973	Waxy	Ignites	....	....	....	....	....	....	0.2934
Strontium	Powder	Yellow	2.5	Above Au	Ignites	....	....	....	Ductile			
Tin	Dimorphous crystals	Very white	7.2	1.2	233°	$\frac{1}{462}$	11th	4th	10th	15.5	14.4	0.0562
Zinc	Tabular	Bluish white	6.9-7.2	1.9	Burns, 420°	$\frac{1}{340}$	9th	9th	9th	28.1	29.6	0.0955

[1] Pb = 1. [2] 0° to 100° C. [3] Ag = 100. [4] Ag = 100.

a gray or blue tinge. Finely powdered metals often lack metallic luster. The alkaline earthy metals are yellowish. Gold is yellow (brown in powder); Cu red; powdered As, Sb, Ag, Pt, and Fe black (pure Fe is silver-white). Bi and Co are white with a pink tinge. Thin leaves of Au and Cu appear green or purple by transmitted light, and molten Au is bluish-green in color. Cast iron is white (rapidly cooled), or gray (slowly cooled), according as the union of Fe with graphite is chemic or physic. Heated Cu and freshly-tempered steel exhibit a rainbow of colors. As and Sb are characterized by a garlicky odor, brought out on heating. Fe, Cu, and Zn also yield an odor on heating. Cu has the most decided metallic taste.

In sp. gr. metals vary from Li (0.59) to Os (22.47). The common alkali metals are lighter than H_2O; Mg and Ca about 1¾ times as heavy; Al and Sr, 2½ times; and Ba, 3¾. These are termed the light metals. The remainder have a sp. gr. above 6 (see table) and are called heavy metals. The sp. gr. of Fe is less the more C it contains: wrought iron, 7.8; steel, 7.6 to 8; cast iron, 7.1. Cast metals are a little lighter than the same in wire or wrought.

Experiment.—Float a piece of Fe on Hg.

In hardness metals vary greatly. The alkali metals are waxy and are easily cut with a knife. Of common every-day metals Pb is softest, and hence is often taken as the unit of hardness (see table). It cuts readily, and when rubbed on a piece of white paper leaves a gray streak. Sn can also be scratched with the finger-nail. Fe and Cu are 2.4 times as hard as Pb, and Ni 2.5 times as hard, being the hardest common metal. Ir is the hardest metal and scratches the best steel. Au and Ag are too soft alone for commercial use; hence they are alloyed, the former with Ag (pale or green gold) or Cu (red gold), the latter with Cu. Au is also toughened by fusing with a flux of 1 part each charcoal and NH_4Cl added to the gold just before melting. Dental instruments of steel can be hardened by coating with soap (to prevent oxidation and scaling), then heating to full redness and dipping into cold water. If allowed to cool slowly, they become soft. Case-hardening for gun-locks, etc., is accomplished by heating the iron object in some substance rich in C (bone dust, K_4FeCy_6), then cooling in water. The inner body retains its toughness.

Aside from Hg, the lowest f.p. is that of Ga (30°), and next to this come Rb (38.5°), K (62.5°), and Na (95.6°). Also fusible below a red heat are Li, Sn, Bi, Cd, Pb, Zn, Mg and Sb. Metals of the alkali earths melt at a red heat. Ag, Cu, and Au require a bright-red or white heat to melt them. The f.p. of Fe varies inversely with the percentage of C it contains. That of cast Fe is about 1200°; steel, 1400°; wrought Fe, 1600°; Ni, Co, and Pd likewise require a high forge-heat to melt them, while

Cr, U, Mo, and W do not melt in the forge, but agglomerate. Pt (1775), Ce, Ir, Ti, Rh, Ta, Ru and Os are infusible in the ordinary blast furnace, but are melted by the oxyhydrogen blowpipe and can be distilled by means of the electric furnace. Fe, Ni and Pt become semiliquid or pasty on heating sufficiently, and hence can be welded. Au can be welded cold. Alloying with other metals lowers the m.p. Mg, Zn, and metals of the alkalies and alkaline earths burn easily. Especially volatile on heating are As, Hg, Zn, Cd, K, Na and Te. At a red heat K is converted into a blue-green vapor. The vapor of Ag and Cu has a beautiful green color. Gold vaporizes at furnace heat, giving a greenish color to the flame. Sb, Cu and Bi have the peculiar property of expanding on cooling. Fe contracts on fusion.

As shown by the table, each metal expands at a definite rate on heating a given number of degrees. Metals as a class are good conductors. Elevation of temperature reduces conductivity. Ag ranks first in conducting-power, both for heat and electricity, with Cu a close second. Strange to say, the conductivity of Cu is reduced by the presence in it of a little Ag. Bi stands at the bottom in these respects. The specific heat of common metals ranges from Bi (0.0308) to Na (0.2934). Al requires about twice as long to reach the same temperature as Fe.

Experiment to Illustrate Expansion.—Heat a ball of brass, which will readily pass through a slightly larger ring, with the Bunsen burner, and try to pass it again through the ring.

Experiment to Illustrate Relative Electric Conductivity.—A chain made of alternate links of Ag and Pt, on connecting with an electric current of sufficient strength, shows red-hot Pt links between cool Ag links.

In tenacity the more fibrous metals (Co, Ni, Fe, Cu) lead. Pb ranks very low in this property. The crystalline metals As, Sb, Bi, Mn, and Zn are noted for their brittle character. The last named is made malleable by heating to 120°-150°; it becomes brittle again at 205°. Heat generally diminishes tenacity.

Wrought Fe is the softest and toughest of the three forms of Fe. It is quite malleable when heated. When heated steel is cooled rapidly it becomes hard and brittle; if cooled slowly it retains its elasticity as well as hardness, and may be forged and welded. It is tempered by heating to 220° or 320° and cooling slowly. Fe and Au increase in tenacity at 100°; less so above this. Au is first and Ag second in malleability and ductility. These properties of Au are much impaired by even minute traces of Pb, Bi, or Sb. A grain of Au can be spread out to cover 54 square inches, and has been drawn into a wire 550 feet long. Great cold renders all metals more brittle. Annealing, or heating and cooling, restores the normal malleability and ductility lost by working. The toughness of gold can be restored by throwing a small quantity of $HgCl_2$ on the molten metal, to convert metallic impurities into volatile chlorids. Pb and Zn are removed in the slag after melting with a mixture of borax and saltpeter. Metals are generally deficient in elasticity, except steel. The addition of a small proportion of Pt to Au greatly increases the elasticity of the latter. The more elastic metals are generally sonorous. Sn and Cd crackle ("cry") when bent, owing probably to the friction of their crystals. Metals and their alloys tend to become crystalline on percussion and other mechanic forces.

Fe is paramagnetic; Mn, Ni, Cr, and Co slightly so. Bi is the most diamagnetic metal. Al and Mg are permeable to the X-rays. Many metals in the molten state absorb or occlude O, giving it off again on cooling, sometimes with "spitting" of the metal. Pt black (best prepared by warming $PtCl_2$ with an alcoholic solution of KOH) can condense 800 times its own volume of O within its pores. Pd on heating to redness in a stream of H absorbs 643 times its own volume of the gas.

Metals, like the metalloids, sometimes assume different appearances and other properties or allotropic forms. As, for example, has a steel-gray crystalline and two amorphous (friable black and gray) forms. Ag may assume a white, black, blue, bluish-green, red, purple, or yellow color. These forms are obtained chiefly by pptg. Ag from solution by different reducing agents. They themselves act as reducers, are soluble in NH_4OH, and are changed to AgCl by quite dilute HCl.

Metals are studied microscopically by polishing, then etching with acids (HCl in alcohol for iron), and so examined by oblique illumination. Fe, from this standpoint, comprises ferrite (pure iron), martensite (hard steel), cementite (Fe_3C, white cast-iron), and pearlite (a carboniferous steel of constant composition, a complex of ferrite and cementite).

Radium, actinium and polonium are more than a million times as radioactive as is uranium, which is used as a standard of comparison. Ra increases the electric conductivity of air and water, by causing dissociation of their molecules. Radioactivity is most marked at low temperatures. It is tested electroscopically or electrometrically.

CHEMIC PROPERTIES OF METALS.

The lighter metals are, generally speaking, more active chemically than the heavy metals.

Solubility.—HNO_3 dissolves all metals except Al, Au, Pt, Ir, Sb (forms antimonic acid), and Sn (forms white metastannic acid—tin nitrate if very dilute). Pb, Ag, and Fe are soluble in dilute but not in strong HNO_3. When Fe or Ni is immersed in the fuming acid, it is rendered passive: *i.e.*, incapable of being dissolved in the weaker acid unless heated or unless some other metal—as Cu, Ag, or Pt—is also present to form an electrolytic current. This passive condition depends on the formation of a coating of oxid formed by the action of oxids of N in the fuming acid. The non-fuming acid yields the same phenomenon when alcohol or some other reducing agent is added. If Pt is alloyed with Ag, HNO_3 dissolves it. A gold-silver or gold-copper alloy containing less than 25 per cent. Au is disintegrated by HNO_3, which dissolves the other metal, leaving Au. If there is more than 25 per cent. Au, enough Ag or Cu must be fused with the alloy (quartation) before the acid will remove all the Cu or Ag.

HCl dissolves all metals except Sb, Hg, Ag, Pb, Au, Pt, and Bi. HCl attacks Cu slowly, only in presence of air. HCl dissolved in benzene has no action on metals, since the acid does not dissociate in this medium.

Dilute H_2SO_4 dissolves all except Sb, Al (soluble on boiling), Pb (slightly), Au, Pt, Cu (soluble in concentrated hot), and Hg (soluble in concentrated). Strong H_2SO_4 forms a coating of sulphate which, not being dissolved away, soon stops chemic action. C.p. Zn is scarcely acted on by dilute H_2SO_4.

Aqua regia dissolves Au (quickly), Pt (slowly), and Sb (also soluble in hot HCl and in hot H_2SO_4). Sn is converted into $SnCl_4$. Gold is soluble in iodic and selenic acids. Insoluble in acids are Cr, Rh, Ir, and Ru.

Caustic alkalies dissolve the weaker metals, Zn, Al, and Sn, forming zincates, aluminates and metastannates. Alkaline hydroxids and nitrates dissolve gold. Pb dissolved in alkalies to form plumbites (radical, PbO_2^{II}); PbO_4^{IV} is plumbate. Pt makes easily fusible alloys with molten metals; it is also dissolved by hot alkalies.

NaCl and organic acids, fats, oils, alcohols, dissolve Zn (often contains As). KCN dissolves Au, Ag, and Cu. Al is dissolved by certain vegetable acids, especially in the presence of NaCl. Ammonia-water dissolves Cu slowly, the process being hastened by allowing access of air. Cu is also attacked by fats and syrups, and by vegetable acids in the presence of air and moisture; hence culinary preparations containing vinegar or lemon-juice should not be placed in Cu vessels. A liter of distilled water may dissolve 3 mg. of Cu, and natural waters more. Al attacks glasses, but can be melted in a clay crucible.

Colloidal solutions of metals are obtained either by the use of reducing agents on metallic salts, or by immersing a bar of the metal in H_2O and passing a strong electric current through the liquid, breaking off minute particles which are held in suspension like an emulsion. These solutions have distinct catalytic or oxidizing properties. Soluble (colloid) Ag is red (moist) or blue (dry). The insoluble variety is blue. White AgCl soon turns violet when exposed to light, due to Ag_2Cl and metallic Ag (insoluble in NH_4HO). Gold can be obtained in a soluble colloid form (violet solution) by the action of a mixture of solution of cerium acetate and NaHO on a solution of $AuCl_3$.

Action of Air.—Noble metals (Au, Ag, Pt, Hg, Pd, Rh, Ru, Os, and Ir) do not oxidize on exposure to air; the rest are termed base. Cu, Zn, Al, and Sn do not oxidize in dry air. Tin is sometimes subject to a sort of contagion, by which it slowly changes (below 20°) to the gray form (sp. gr. 5.8), which can be changed back by heating to the ordinary white variety.

In moist air Zn and Mg become covered with a film of oxid (prevents further change); Cu with a green deposit of basic carbonate; Pb with a blue-gray coating of carbonate and sulphid. Iron-rust, that forms in moist air or H_2O, is a mixture of $Fe(HO)_3$ and Fe_2O_3. The rusting of iron or steel is due to the action of acid (H) ions in water, and can be prevented by treating with some oxidizing agent like $K_2Cr_2O_7$. If the plating of Sn on Fe is worn away at any point, it oxidizes more quickly (galvanic action) here than on a uniform iron surface. Zn is more positive than Fe; hence galvanized iron does not easily rust. Tarnishing of silverware is due to the formation of Ag_2S by the H_2S in the air of houses; Cd turns yellow from the same cause. Alkali metals oxidize very quickly, and must be kept in oily liquids (or benzene) that contain no O.

Action on Water.—Metals of the alkalies and alkaline earths decompose H_2O, sometimes with a colored flame of H, and form hydroxids:—

$$K + H_2O = KHO + H$$

Na must be kept at rest on the water by means of a piece of filter paper. Zn in air or water shows first a film of oxid, then a coat of carbonate and hydroxid, which does not dissolve in water unless containing chlorids.

Red-hot Fe dipped into H_2O decomposes the steam that is formed, setting H free and producing the "blacksmiths' scales" of Fe_3O_4. Powdered Mn also decomposes H_2O. Pb is slightly soluble in H_2O, and this solvent action is increased by the presence of chlorids, nitrates, and nitrites, and decreased by carbonates and sulphates, which form an insoluble coating on the inner surface of the pipes. Generally speaking, the softer the water, the greater the danger of Pb being dissolved by it. Sn, Zn, Fe, and Mg ppt. Pb from its solutions.

Experiment.—Make a "lead tree" by dipping a strip of Zn into a solution of lead acetate.

Normal salts of Bi decompose on the addition of much H_2O, with ppt. of oxysalts or subsalts. Oxids of metals combine with H_2O to form hydroxids (rarely acids, when there is a very large proportion of O), and both oxids and hydroxids combine with acids to form salts. The presence of air favors the solution of metals by acids or bases.

Direct Combination.—All metals unite directly with Cl, F, and O; most with Br, I, and S; many with C and P and As. Freshly prepared ferrum reductum burns readily with a red glow. Hg and O do not react on each other at ordinary temperatures, but when the metal is heated nearly to its b.p. it combines slowly with O, forming HgO, which breaks down quickly into Hg and O at a low red heat. Powdered Zn or Mg reduces many other metals from their salts on heating. A strip of Zn, Sn, or Fe ppts. Pb or Bi from solutions of their salts; a stick of P or other non-metal collects crystalline Au from a heated solution of one of its salts; Zn, $FeSO_4$, $H_2C_2O_4$, and H_2SO_3 also ppt. Au. Hg dissolves all other metals directly or indirectly (Na amalgam) except Fe, forming weak chemic compounds known as amalgams. The platinoid metals and tin seem to unite chemically on heating. Pd shows a stain on heating with a drop of tincture of I; Pt is not affected.

Experiment.—Clean a copper cent with HNO_3, and spread on a globule of Hg to "silver" it. Why does it turn green later?

Molten cast iron dissolves C, forming a carbid. The chief impurities of cast iron are S, which renders it brittle when hot ("red-short"), and P, which renders it brittle when cold. Sb and As unite readily with most metalloids and with many metals, thus playing both the + and the — rôle. Both form poisonous combustible gases (H_3Sb and H_3As) with H. Cu on heating becomes coated with black CuO. Mg burns readily with an intense white light rich in actinic rays.

Al combines with O at high temperatures, giving a great heat and a brilliant light. Zn is also combustible at a bright-red heat. Cd burns under the blowpipe, leaving the brown oxid. As and Sb burn with a bluish-white light and garlicky odor; Te with a blue flame tinged with green; In with a violet flame. The alkaline and alkaline earthy metals also yield characteristic flames (see "Pyrology"). Ozone and H_2O_2 corrode most metals by breaking up and giving off nascent O.

Series of Salts.—Apt to change spontaneously, one into the other.

Ferrous and Ferric.—In these two series the metal is a diad and a triad, respectively.

Ferrous compounds are usually greenish in color; ferric salts, reddish. They undergo spontaneous change, one class into the other, on exposure to the air, as well as by artificial reduction or oxidation.

Experiment.—Convert $FeSO_4$ into $Fe_2(SO_4)_3$ by heating a solution of the former with dilute HNO_3, and note corresponding change in color.

Ferrous salts can be made by dissolving Fe in the corresponding acid; ferric salts, by dissolving Fe_2O_3 in the acid of the salt desired. Fe salts are combined with sugar to obviate astringency and irritating qualities and prevent oxidation.

Mercurous and Mercuric.—In mercurous compounds Hg acts as a monad; in mercuric, as a diad. The *ous* salts are probably unsaturated as to valence, and are prone to decompose into metallic Hg and the corresponding *ic* compound. To preserve the *ous* salts a little Hg is usually added.

Cuprous and Cupric.—The *ous* and *ic* salts of Cu correspond in structure to those of Hg. Cuprous compounds are even more unstable than mercurous ones.

Cobalt Salts.—Hydrated Co salts give pink solutions; anhydrous ones blue.

Experiment.—Make sympathetic ink by dissolving some $Co(NO_3)_2$ in water. Write with this solution and a glass rod on white paper and let dry. The writing is invisible. Now dehydrate by holding the paper near the flame, and the characters will appear plainly in blue.

Ammonium Compounds.—These on exposure to the air give off the gas NH_3; hence the term volatile alkali applied to this metal.

Experiment.—With moistened red litmus-paper, held above the open neck of the bottle, show volatility, of NH_4HO, and notice that the red color is restored on drying.

Ammonio-copper compounds are double salts of Cu and NH_3 and yield deep blue solutions. Examples are cupric-diammonium sulphate, $CuSO_4(NH_3)_2$, and cupric-tetrammonium sulphate, $CuSO_4(NH_3)_4$. Silver-ammonium compounds are likewise double soluble salts. Chromous salts are blue; chromic, green. Chromic acid is red or yellow. Dimanganion is pale red or pink. Trimanganion is violet-red; its salts quickly hydrolyze into brown $Mn(OH)_2$.

Zinc salts are all white, as are nearly all the salts of the alkaline and alkaline earthy metals.

Magnesium salts are soluble in the presence of ammonium compounds, with which they form double salts.

Organic metal compounds and double salts of metals are non-irritant and do not ppt. albumin.

Scale Compounds.—These are chiefly ferric salts with organic acids, which prevent pptn. of hydrates by the heavy metals. They are prepared by evaporating to a syrupy consistence, pouring on plates, and peeling off when dry. Official are ferric citrate, soluble ferric phosphate, ferri et ammon. cit., ferri pyrophos., ferri et quin. cit., ferri et strych. cit., ferri et ammon. tart., and ferri et potassii tart. They are green or red in color.

Actinism.—Ag salts are very susceptible to the action of light, being reduced to the black, finely divided subchlorid Ag_2Cl, especially in the presence of organic matter.

Experiment.—Show silvering of glass with solution of Rochelle salt, strong $AgNO_3$ solution, and enough NH_4HO to nearly dissolve precipitate, warming carefully.

Radioactive Metals.—Radium, thorium, actinium and polonium are present in minute quantities in the ores of uranium. All of them emit luminous rays capable of passing through opaque substances, producing electric effects, acting on photographic plates and on the human body therapeutically.

Owing perhaps to subatomic disintegration, radioactive compounds give out light (non-luminous preparations also), heat (1.5° above their surroundings—melt their own weight of ice in an hour) and chemic waves indefinitely. They penetrate opaque objects, affect photographic plates and cause phosphorescence in a fluorescent screen and in the lens of the eye. They lose their radioactivity temporarily by being kept several hours in a vacuum or by prolonged heating at 1000° C.; great cold enhances radioactivity. Paper becomes brittle on exposure to radium rays, sodium glass is turned a deep violet, plant leaves wither, and yellow phosphorus becomes red.

The important alpha radium rays (Rutherford) are readily absorbed and are positively charged; they cause the scintillations. The beta rays are the same as cathode rays. A third class (gamma rays) seem to be identic with X-rays, and are without electric charge. These rays are thought to be produced by sudden stoppage of the charged electrons, just as a like stoppage of the cathode rays in a vacuum tube causes ether-pulses, or X-rays, on the outside of the tube. In penetrating effect, the gamma rays rank first, passing through three inches of lead or eight inches of iron.

Besides these three kinds of rays, there is a gaseous emanation which can be blown about. This emanation may consist in the projection of entire atoms (as with a perfume), and these, alighting on any exposed surface, may disintegrate and so render the substance apparently radioactive for the time. In this connection helium is formed (Ramsay), probably by the rearrangement of fewer electrons. Solutions of these salts evolve helium continuously.

PHYSIOLOGIC PROPERTIES OF METALS.

None of the metals have any distinct action on or in the body until converted into compounds by the digestive juices or otherwise. Hg is most employed, either rubbed with chalk (gray powder), or with lard and suet (mercurial ointment) or with licorice-powder and rose honey ("blue pill"). The therapeutic alterative activity of these preparations is due to Hg_2O formed by oxidation of the finely divided ("dead or extinguished") metal. Hence the better rubbed and the older, the stronger they will be.

Salts of the less positive metals, Zn, Al, Cu, Fe (vegetable acid salts not constipating), and Pb (also sedative) are generally astringent, especially the sulphates. Bi salts are soft and insoluble; hence used as mucous-membrane sedatives. Mg salts are generally laxative and antacid. Fe is an essential element of blood-corpuscles, and is therefore much used as a hematinic. As is a valuable alterative and nerve-tonic. Liquid As official preparations are of 1-per-cent. strength; dose, 2 to 10 minims. Many metallic salts, particularly of Bi and Fe, when taken internally blacken the stools by uniting with H_2S in the intestines.

The salts of the alkali metals are white and solid and mostly fusible at a red heat. Practically speaking, all are soluble in H_2O, but much less so or not at all in alcohol. The hydroxids and carbonates are peculiar in not being decomposed by heat. Most K salts are deliquescent; most Na salts efflorescent. K compounds are the strongest physiologically and the most irritating and depressant. The stimulating properties of NH_4 compounds depend largely, no doubt, on the contained N. The various salts of each metal are usually prepared by treating the most abundant and accessible compound with the acid of the salt desired or with a solution of some reagent containing the desired radical. The salts of the alkali metals are the most common and useful mineral medicines. They are used as cathartics and antacids, and even more as suitable vehicles for the administration of medicinal negative elements: *e.g.*, NaBr for Br, KI for I, etc. The alkaline salts of the vegetable acids are oxidized into carbonates in the system.

The common Ca compounds are essential to the life and growth of all living beings. Sr is preferred as a base for I, Br, and salicylic acid, since it is non-irritant to the stomach. Salts of the heavy metals generally are changed into albuminates before absorption into the blood; hence are often advantageously given in milk. Caustic alkalies act as corrosive poisons; large doses of heavy metals (except Fe) act as irritants chiefly. Most of the heavy metals may give rise to chronic poisoning due to medication, occupation, or environments. Hg and As vapors are extremely poisonous. Metals of the same group vary in toxicity directly as their atomic weights. Mineral substances tend to accumulate in the body more than vegetable.

The therapeutic effects of radioactive salts appear to be due to the inhibitory action of the rays emitted on the trophic nerves supplying the part or tumor. Radium affects the sense of vision, even when held behind the head. It exerts an irritating influence on the skin, producing dermatitis, and darkens arterial blood.

USES OF METALS.

The most important of the industrial metals are Fe, Al, Cu, Zn, Sn, and Pb. Fe is the most useful metal, and is employed in innumerable ways. So necessary has it been to the progress of the race that the historic period of the earth is often styled the iron age. Wrought or bar Fe is of special use for building purposes and Bessemer steel; white cast Fe for forging, puddling, and steel; cement steel for armor plates; carbon or crucible steel for springs, tools, and firearms; open-hearth or low-carbon steel for tires, tanks, fire-boxes, etc.; and Bessemer steel for rails and construction material.

The metal Al is the best suited of all metals for culinary vessels, on account of its lightness and because it does not tarnish nor is acted on by vegetable acids so much as Zn, Sn, and Cu are; it is, moreover, not at all poisonous. Al is also employed for covering roofs and monuments, for ornamental purposes (silvering—thin leaf), and in dental plates, and is sometimes used with S in vulcanizing rubber. Powdered Al is used in white paints for metal surfaces, and for welding the joints between rails (along with oxid of iron—as thermite).

Zn is used in the manufacture of brass, desilvering Pb, in dental dies and counter-dies, electric batteries, and for coating or "galvanizing" sheet iron for roofing, pails, tubs, etc. The Fe is cleansed in dilute H_2SO_4 and then dipped into molten Zn.

Cu is utilized for money, electric wires, cartridges, various utensils, in sheathing ships, and to give a ruby color to glass. Its alloys are of extensive service.

Tin plate consists of sheet Fe coated with Sn; if the coating is thick, it is styled block tin. Pins are made of brass wire covered with tin amalgam. Tin-foil is made of Pb between thin strips of Sn. In much of the ordinary tinware the coating of Sn is adulterated with Pb, and rusts more quickly than it should. Pure tin-foil is sometimes used as a dental filling. The insoluble SnO_2 formed between the wall and the filling acts as a preservative. Sn has but slight affinity for S, and is much used in packing rubber articles and for models of vulcanite dentures and in coating plaster casts for the vulcanizing process.

Pb is used very extensively in the manufacture of shot, bullets, water-pipes, chemic vessels, dental counter-dies, and various alloys, notably solder and type-metal. Cylinders of Pb have been used for filling the root-canals of teeth.

Of secondary importance in manufacture are Mn, Cr, Ni, Co, As, Bi, and Sb. The chief use of Mn is in making ferromanganese for the Bessemer steel process. The toughest, hardest steel contains about 15 per cent. Mn. Manganese steel, being non-magnetic, is used in making dynamos. Cr is used in the proportion of 0.5 to 0.75 per cent. to harden steel. Ni is utilized as an anti-rust plating for steel and Fe instruments and in armor-plate. The principal use of Co is in making the blue pigment smalt, by fusing some salt of this metal with finely-powdered glass. As (½ per cent.) gives the round shape to bullets. A mixture of Co ("glance") and As is used as fly-stone and black fly-paper. As is also used in fireworks. Bi is employed largely in fusible alloys (safety-plugs), in dies for wood-cut and stereotype impressions, and in dental dies and counter-dies. Sb is used in type-metal because it expands on cooling, and in various other alloys. U salts color glass and render it fluorescent.

Mg is of service in photographing objects in dark places; also for flashlights (powdered Mg blown through a flame or ignited with $KClO_3$), and signaling, in the Bengal fires and pyrotechnics. It is sometimes substituted for Zn in Marsh's test.

K and Na, on account of their strong attraction for negative elements, have been used in the separation from their ores of other elements, particularly Mg, Al, B, and Si. Na is a common laboratory reducing agent. Na amalgam is often employed in place of the single metal.

On account of its density and wide range of fluidity, Hg is much used in making thermometers, barometers, and other scientific instruments. Its avidity for Au accounts for its use in placer mining. An amalgam of Sn and Hg is used for coating the backs of mirrors.

The value of the precious metals Au, Pt, and Ag depends partly on their comparative rarity and partly on the fact that they do not readily fuse or oxidize. Ag is made use of widely in the manufacture of surgical instruments and sutures, being itself slightly antiseptic. It is further used for certain chemic apparatus, for coins, electroplating, the silvering of glass for mirrors, and as the source of Ag salts. Ag coins are alloyed with 10 per cent. of Cu to give the needed hardness. The silver electroplating solution consists of 1 part of $AgNO_3$ in 50 H_2O, combined with 5 KCN in 20 H_2O; the AgCN thus formed, though insoluble in H_2O, is soluble in the excess of alkaline cyanid. The Ag bar attached to the + pole is gradually dissolved by the CN liberated at the same pole, keeping the proportion of AgCN in the solution about constant.

Au is used as coin and for jewelry, on account of its softness being alloyed with Ag and Cu. The fineness of Au is represented in carats, the pure metal being designated 24 c. fine. United States gold coins are 21.6 c. fine; jewelry usually 14 c. Gilding is performed by means of electrolysis of a solution containing $AuCl_3$ and KCN. Glass and porcelain are decorated in the same manner or with the purple of Cassius (made by reaction between $AuCl_3$ and $SnCl_2$). Gold salts are used in photography for toning. The gold leaf used by dentists and sign painters is prepared by passing Au between rollers till about $\frac{1}{300}$ inch thick, then hammering between calfskin vellum till $\frac{1}{160000}$ to $\frac{1}{200000}$ of an inch in thickness. The cohesive Au used for dental fillings is prepared by heating gold-foil to redness (on a sheet of mica), thus restoring the cohesive properties lost by beating, and driving off moisture and gases from the surface. The "soft, non-cohesive gold" preferred by some for dental purposes is prepared by alloying or by depositing carbon on the surface.

Dentists generally employ gold plate of 18 to 20 c. fineness, the remaining 4 or 6 c. being made up of from two to six times more Ag than Cu. If a higher carat is desired for greater tenacity (clasps and wires), a little Pt is added, and the Cu exceeds the Ag. Gold plates should be "pickled" in dilute HNO_3 after swaging, in order to remove every particle of die metal.

On account of its high m.p., Pt is much employed for crucibles, evaporating-dishes, stills (H_2SO_4), flame-test wires, and in electric apparatus. An alloy with Ir is harder, less fusible, and less subject to chemic action than is the pure metal. Pt is used to some extent for ornamenting porcelain. It is also employed in dentistry for pins for artificial teeth, for continuous gum-plates, and when finely powdered for coloring artificial teeth. $MgCl_2$ solution, heated to dryness (forming HCl and MgO), is excellent for cleansing platinum.

The rare metals are mainly of theoretic interest. Pd is used for mounting scientific instruments and plating silver goods. It is non-magnetic and its elasticity is not affected by changes in temperature, hence it is used in the hair-springs of watches. Va salts give a gloss to satin and are used to set black in fabrics. Ta is used for the filaments of incandescent lamps. Ce and Th are used in the manufacture of Welsbach mantles for gas burners and in making steel for manufacturing tools.

METALLIC GROUPS.

Alkali Metals.—This includes K, Na, Li, NH_4, Rb, and Cs. The group is so called because the oxids, hydrates, carbonates, and some phosphates of the metals composing it are of an alkaline reaction. All are univalent, and the first three are lighter than H_2O, which they deoxidize, forming hydrates and setting free H. They are soft, silver-white, easily fusible, and volatilize at high temperatures. They are strongly positive; hence have a great affinity for negative elements. Their salts are all practically soluble, and increase in physiologic potency with the atomic weights of the metals.

Metals of Alkaline Earths.—These include Ca, Ba, and Sr, and (for present convenience) Mg. They are all diads. They burn readily and decompose H_2O at high temperatures. HCl and dilute H_2SO_4 dissolve them. Their halogen salts are freely—their sulphates, oxids, and hydrates slightly (except $MgSO_4$)—soluble in H_2O; carbonates, phosphates, and borates insoluble.

Lead Group.—This comprises Pb, Cu, Bi, Ag, Hg, and Cd. These metals are soft and heavy. Their sulphids are black and insoluble in H_2O, dilute acids, and NH_4HS; their halogen salts slightly, if at all, soluble. The carbonate and sulphate of Pb are also insoluble.

Aluminum Group.—Al, In, Ga. These are practically trivalent. Their double sulphates are called alums. Their oxids are insoluble.

Iron Group.—Fe, Mn, Co, Ni, Cr, Zn. These are divalent or trivalent and more or less magnetic. Their sulphids are soluble in dilute acids.

Arsenic Group.—As, Sb, Sn, Au, Pt, Mo. Their sulphids are insoluble in dilute acids; soluble in NH_4HS. Sb_2S_3 is soluble in strong HCl, insoluble in NH_4OH (As_2S_3 soluble).

ALLOYS IN GENERAL.

A combination of metals fused together is termed an alloy; a solution of a single metal in Hg, an amalgam; a solution of an alloy in Hg, an amalgam-alloy. Some of them are probably feeble and indefinite chemic compounds, forming crystals, but most appear to be mechanic mixtures or solutions. In preparing alloys the least fusible metal should be melted first, and the next least fusible added little by little with constant stirring, preventing oxidation with borax or charcoal, and reducing the heat gradually according to the fusibility of the metal next added.

Experiment.—Make Na amalgam by adding a piece of this metal to Hg in a mortar, rubbing and pouring off excess of Hg. Note needle-like crystals of the amalgam.

Alloys generally have a lower fusing-point than the mean of their constituents; sometimes lower than any single constituent. Alloys of Pb, Sn, Hg, Cd, and Bi are noted for their fusibility. Wood's fusible metal melts at 68°; Rose's metal at 94°; stereotyping metal in boiling H_2O. Soft solder melts at 186° (Sn, 233°; Pb, 326°). An alloy of K and Na is liquid at ordinary temperatures. Fusible alloys are useful in dovetailing teeth into old rubber and celluloid plates with the aid of a warm burnisher. Fluxes are substances added to ores to aid in reduction by lowering the m.p. in this way.

Alloys are usually harder than the hardest metal composing them. Even the addition of such soft metals as Sn and Pb generally hardens other metals. Cu is added to Ag and Au for this reason. Au for artificial dentures is reduced with Ag and Cu to 18 carats.

The alloy iridosmine, on account of its hardness, is used to tip ("diamond points") gold pens, the particles being pushed into the point of the pen while cold. Al bronze is employed for castings, and is added to steel, Zn, and Ag to improve these metals in hardness and tenacity. Phosphoriridium, made by heating these two elements together, has great power of retaining lubricants. It is used to point stylographic pens. An alloy with 50 per cent. of Fe is not scratched by the best file. Silico-copper is as hard as steel.

COMMON ALLOYS.

NAME.	PARTS IN 100.															
	GOLD.	SILVER.	COPPER.	TIN.	ZINC.	LEAD.	ALUMINUM.	NICKEL.	ANTIMONY.	BISMUTH.	MERCURY.	SPELTER.	CADMIUM.	IRON.	MANGANESE.	PHOSPHORUS.
U. S. Gold Coins	90		10													
U. S. Silver Coins		90	10													
Minor Coins			75				25									
Flagg's Submarine Alloy		60	5	35												
Nürnberg Gold	2.5		90				7.5									
Dutch Gold			84.5		15.5											
German Silver			60		20			20								
Brass			66.6		33.3											
Bronze			91	2	6	1										
Aluminum Bronze			90				10									
Manganese Bronze			75		5										20	
Phosphor-bronze			90	9												1
Bell-metal			80	20												
Gun-metal			90	10												
Hercules Metal			88[1]		2	10	2.5									
Babbitt-metal			9	73					18							
Britannia			1.84	81.9					16.25							
Pinchbeck			85	15												
Pewter				80		20										
Ferromanganese														75	25	
Type-metal				16.5		67			16.5							
Swaging Dies				20	80											
Fusible Alloy				31		19				50						
Wood's Metal					12.5	25				50			12.5			
Rose's Metal				25		25				50						
Melotte's Metal				5		3				8						
Soft Solder				60		40										
Plumber's Solder				33.3		66.6										
Dental Solder				45			45				10					
Bismuth Solder				40		40				20						
Brass Solder			75[2]		25											
Silver Solder		73	9		18											
Gold Solder	83	9	4									4				
Aluminum Solder			4		90		6									

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[1] Bronze. [2] Brass.

The tenacity of metals is sometimes diminished, but usually increased, by alloying, as illustrated by Al bronze. Steel is 2½ times as tenacious as iron. The addition of 12 per cent. of Sn to Cu trebles the tenacity of the latter. Sb, Bi and As render alloys brittle, and even a trace of Pb makes Au much less ductile and malleable. By adding 5 per cent. Ni to steel, the tensile strength is increased about one-half. Invar is an alloy of steel with 36 per cent. of Ni, used for hair-springs.

The color of alloys is commonly gray, but is sometimes superior to that of their constituents. Thus, brass has a better hue than Cu, is less subject to atmospheric action, and is more easily worked in the lathe. Al bronze resembles Au. Equal parts of Sb and Cu fused together yield a violet alloy. Metallic luster is often modified or even destroyed by alloying. This is particularly true of Au. Different grades of brass (Zn and Cu) include similor, Bath metal, Mannheim gold, Prince Rupert's metal, Muntz's sterro, and Aich's and Gedge's metals. The Chinese alloys pacfong and tutenag contain Zn, Cu and Ni. Ni added to brass produces a silver-white alloy. The greenish alloy used by jewelers has 30 per cent. Au and 70 per cent. Ag. "Red gold" is ¾ gold and ¼ copper. "Blue gold" is said to contain 75 per cent. Fe. Cu and Pt in equal proportions form an alloy like gold in color and density.

The sp. gr. of alloys nearly always varies from the average of their constituents. An alloy of Ag and Au is below—one of Pb and Sn above—the mean of its constituents.

Liquation is the term applied to the gravity phenomena whereby the metals composing an alloy form separate layers when the molten mixture is allowed to cool slowly. Pb and Zn, or Pb and Ag, or Cu and Ag can be parted in this way. When metals differ greatly in fusibility it is best to unite first those that combine most readily.

The property of sonorousness, in which most single metals are deficient, is much enhanced by alloying. Examples are bell-metal and an alloy of Cu and Al.

Elasticity may sometimes be increased by adding a small proportion of other metals. "Spring gold" contains a small percentage of Pt and is used for clasps of artificial dentures.

Alloys of Zn or Hg and other metals (except Pb and Sn), are accompanied by heat. The specific heat of an alloy is the mean of the specific heat of the component metals. Conducting-power for heat and electricity is generally reduced in alloys. The coefficient of heat-expansion in alloys is usually about the average of its ingredients. An exception is copper-tin alloy, which expands less than pure Cu, although Sn alone expands more than Cu.

The solubility of alloyed metals is often considerably altered. The action of acids is generally more marked than upon a single metal. Ag becomes insoluble in HNO_3 when alloyed with more than 25 per cent. of Au, and Pt becomes quite soluble in HNO_3 when alloyed with Au or with ten times as much Ag. Alloys of Sn and Pb and the tin-silver amalgam-alloys used for filling teeth are readily tarnished or oxidized. A volatile metal (Hg, Zn) can be separated from an alloy by heating at a bright-red heat. P and As added to alloys of Cu and Zn have a deoxidizing effect on the oxids present. Many amalgam compounds can be decomposed by pressure, and all by high temperatures.

Experiment.—Dissolve a 10-cent piece in HNO_3. What color is produced, and why?

Among miscellaneous alloys may be mentioned delta metal (55 Cu, 41 Zn, 4 Co); magnalium (80 Al, 20 Mg); speculum metal (6 Cu, 3 Sn, 1 As); antifriction metal (Cu, Sn and Sb in various proportions); Lichtenberg's metal (5 Bi, 3 Pb, 2 Sn), f.p. 92°; and Newton's metal (8 Bi, 3 Pb, 2 Sn), f.p. 94.5°.

Dental amalgam-alloys, used for fillings, are usually composed of 65 (40) parts Ag and 35 (60) parts Sn. This type may be modified by the addition of a few per cent. of spongy Pt, Cu, Au, Zn, Pd, Al, Sb, Fe, or Cd. The advantages of an amalgam-alloy over a simple amalgam are that opposite properties—for instance, expansion and contraction—may neutralize each other, and also help to set more quickly. An amalgam may be prepared (1) by bringing the metal or alloy in contact with Hg; (2) by adding Hg to the molten alloy; (3) by action of the metal on a salt of Hg; (4) by action of Hg on a salt of the metal. The third method is illustrated when metallic instruments are immersed in $HgCl_2$ solution. The time of setting varies from hours to days, according to the ingredients and whether the excess of Hg has been squeezed out or not, using chamois or good muslin.

Discoloration of amalgam fillings is due to H_2S from decomposing food in the mouth. Ag, Cu, and Pd are blackened; Cd turned yellow. The Ag_2S thus formed is antiseptic, serving to preserve the teeth. The discoloration of gold fillings is said to be due to oxidation of the steel worn from pluggers. Galvanic action between the ingredients of fillings may also have something to do with their discoloration and disintegration, especially when Cu is present. Cu amalgams waste, because the black oxid and sulphid on the surface change to the soluble sulphate, yet the antiseptic action of the salts renders such fillings permanent. Al amalgam in the presence of moisture swells up and decomposes into Al_2O_3 and Hg, with production of heat.

The black "dirt" that is given off in mixing ordinary amalgam-alloy is a lower oxid of Sn, and is more abundant after annealing. Pressure on solid amalgams causes a yielding or flow, which varies with the amount of stress. "Electric amalgam" is commonly prepared with 1 part each of Sn and Zn and 3 parts Hg.

Some alloys expand during setting; others contract. By repeated annealing of 65 to 75 per cent. silver-tin alloys, these show little or no expansion-contraction range. Ice water or ice cream in the mouth contracts dental fillings; hot drinks expand them in the direction of least resistance, and on cooling they shrink in all three directions. In either event a space of several μ is left on each side of the cavity. The micro-organisms concerned in dental caries measure only 0.4 to 0.8 μ.

Dental solders are special alloys for joining metallic surfaces. They usually consist of the metal to be soldered, with another to lower the fusing-point. Hard solders fuse at or above red heat; soft solders below this point. By autogenous soldering is meant the fusing together of contiguous parts of the same metal, usually Pb or Pt. Soft solders are used in the stick form; hard solders in ingot filings; Au and Ag solders as clippings from rolled sheets. They are prepared in a crucible in the same manner as other alloys.

Experiment.—Prepare gold solder by taking 3 parts each of Ag and Zn and 18 parts Au. Place the Au and Ag together in a crucible, cover with ¼ to ½ inch of borax, and melt with blowpipe in furnace. Remove from furnace, and drop Zn through borax into molten alloy. After about one-half minute the fluid mixture is poured into a warmed and oiled mold, and the borax cake picked off.

The best tin solder for dental use contains 1 Pb and 2 Sn, and melts at 171°. Bi solders are composed of Bi, Sn, and Pb, and melt at from 95° to 160°. Really good Al solders are not to be had at present. As a dental solder Hall recommends a combination of 45 parts each of Al and Sn and 10 parts Hg, the solder being applied with a brazing blowpipe and a piece of steel wire. Fused AgCl is used as a flux. Al bronze is readily soldered with alloys of Au, Ag, and Cu.

Brass solder is hard, and varies from yellow to white according to the amount of Sn. Silver solders consist of Ag alloyed with Cu, Zn, and Sn, and are used in soldering Ag, German silver, brass, cast iron, and steel. For general use an alloy of 8 Ag, 1 Cu, and 2 Zn is recommended. Essig gives a formula consisting of 60 parts Ag, 30 parts Cu and 10 parts Zn. For soldering steel 3 parts Ag and 1 part Cu is mentioned by Brandt.

Gold solders range from 12 to 20 c. in fineness, the remainder being made up of Ag and brass in nearly equal proportions. For crown and bridge work Essig commends a solder containing 20 Au, 2 Ag, and 1 each Cu and spelter (equal parts Cu and Zn).

Soft solders are generally applied with a clean and tinned Cu bit. A brazing blowpipe is used for hard solders. The surfaces to be united are commonly "pickled" in dilute HCl or H_2SO_4. Rosin or soldering fluids, such as a saturated solution of Zn in HCl, are employed with soft solders as protective fluxes. A thin paste of borax and H_2O is used, as a rule, with hard solders. The oxidizing flame should be avoided in soldering. Discoloration by such oxidation can be removed with borax or with a warmed solution of dilute H_2SO_4. Pure gold is used as a solder in uniting pieces of Pt or iridio-platinum.

The conditions of successful soldering (Essig) are: 1. Contact of the two pieces to be united. 2. A clean metallic surface over which the solder is to flow. 3. A freely flowing solder. 4. Proper amount and distribution of heat. Borax made into a cream with water and applied by means of a camel's-hair brush is of service in making pieces of solder adhere in proper position. Surfaces to be soldered should be kept especially from contact of plaster of Paris. As a support a solid piece of charcoal, bound with wire and coated on all sides except that for soldering, with a half inch of plaster, is useful. Pumice stone is also of service in holding small objects before the blowpipe.

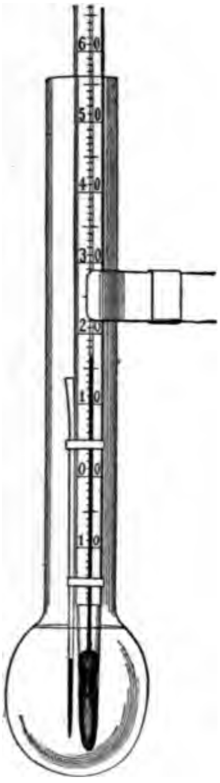


Fig. 23.—Apparatus for Determining the Melting-point of a Solid.

Dental dies are made of Zn or Babbitt metal (1 Cu, 2 Sb, and 8 Sn), Spence's metal (FeS melted in S), or type-metal (1 Sb, 1 Sn, and 4 Pb). Alloys for counter-dies usually consist of 1 part Sn and 7 parts Pb. Richardson recommends for dies for swaging plates an alloy of 4 Zn and 1 Sn.

Experiment to Determine the Melting-point of a Fusible Alloy.—Place alloy in a test-tube, to which is bound a thermometer, and immerse both in a beaker of H_2O. Heat the H_2O, with constant agitation over a hot plate, till the alloy melts. Then let cool and note temperature at which the alloy solidifies. If the alloy does not fuse at or below the b.p. of H_2O, raise this point by saturating with NaCl or NH_4Cl or by using some liquid (glycerin or H_2SO_4) with a higher b.p. than H_2O.

METALLOIDS.

These elements differ from the metals by taking generally the electronegative rôle. Their oxids are acid in reaction. Some of them are gases, one (Br) a liquid, and a number solids.

HYDROGEN.

Though, strictly speaking, a gaseous metal, H will, for convenience, be considered with the metalloids. The element is so called because, in connection with O, it forms water. It was first observed by Paracelsus in the sixteenth century. It was carefully investigated by Cavendish in 1766, who termed it inflammable air, and later demonstrated that it formed H_2O with half its volume of O.

H occurs free in Nature in small quantities, occluded in meteorites, in carnallite, and in volcanic and other natural gases. It is one of the products of decomposition of organic substances, and hence is found in the lungs, stomach, and intestines, and in sewer-gas. It is believed to be the chief constituent of the solar atmosphere. The compounds of H with other elements are very numerous and important, including water, ammonia, marsh-gas, all acids and acid salts, hydrates, and most fuels and substances used for lighting, as well as sugars, starches, and hydrocarbons.

It may be prepared from H_2O by electrolysis or by the action of metals (Na, for example) that have a great affinity for O. The usual method of production is by treating granules of Zn with diluted (1 to 5) H_2SO_4 or HCl:—

$$Zn + H_2SO_4 + H_2O = ZnSO_4 + H_2O + H_2$$

It is collected by displacement over water. The process of evolution is hastened if an inert, more electronegative substance, such as Cu or $PtCl_4$, is immersed in the fluid. H is also evolved on heating certain metals (Zn, Mg, and Al) with strong solutions of alkaline hydrates. It is prepared on a large scale for manufacturing purposes by passing steam over iron turnings or charcoal in an iron tube.

H is a colorless, odorless, tasteless gas. It is the lightest substance known; hence is taken as the unit of atomic weight and density. Air is nearly 15 times as heavy. A liter of H at 0° and 760 mm. pressure weighs a crith: equivalent to 0.0896 gm. H is the most difficult of gases to liquefy, having been condensed by Dewar in 1898 to a steel-blue liquid under a pressure of 600 atmospheres at — 140°. This liquid is the lightest known (sp. gr., 0.07) and boils at — 238°. It has been solidified at about — 256°. Dewar has found that seeds of wheat, barley, peas and mustard do not lose their germinative power by putting them into liquid H.

H is the most diffusible of gases, has the greatest specific heat (3.4), is the most refractive of gases, and the best gaseous conductor of heat and electricity. One volume of the gas dissolves in 50 of water. It is readily absorbed or occluded by a number of metals, particularly Pt and Pd (forming an alloy), the latter metal taking up 400 volumes of the gas, and the former (in the finely divided or spongy state) has so great an avidity for this gas as to ignite it through the heat produced by its rapid absorption.

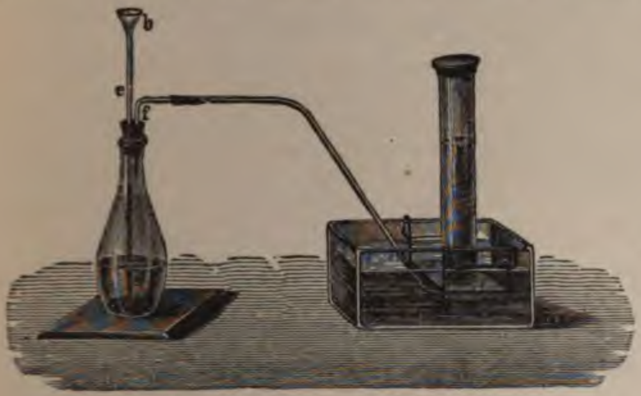


Fig. 24.—Preparation of Hydrogen.

Experiment.—Make H and pass gas on to a disk of spongy Pt till ignition takes place.

In its chemic relations H generally plays the positive rôle, especially in acids, and is displaced from its combinations by metals which are more electropositive. H is not a supporter of combustion, and at ordinary temperatures has little affinity for O, but is quite combustible at elevated temperatures, burning with a pale-blue flame and forming H_2O; when mixed with air or O, it explodes with violence. On account of its avidity for O and other non-metals, heated H is a powerful reducing agent. Nascent H unites with solutions of As and Sb to form inflammable gaseous compounds.

H gas is neither noxious nor beneficial physiologically. It can be inhaled for a short time without injury, producing only a peculiar change in the voice: *i.e.*, a higher pitch, due to more rapid vibration of vocal cords in rarer atmosphere.

Experiment.—Make H and show properties of combustibility, but not supporting combustion, levity, and diffusibility. Take care to expel all air from flask before igniting.

Test.—$O + H_2 = H_2O$, shown by holding cool glass vessel near burning jet.

Combined with O by means of the oxyhydrogen blowpipe, it yields a very intense heat, sometimes used for fusion and reduction purposes. Reduced iron, or Fe by H, is prepared in this manner. H was formerly utilized for balloons, having a lifting power of a little more than one ounce to the cubic foot, but has proved too diffusible to be of much service in this connection.

HELIUM.

This gaseous element was first discovered in the solar atmosphere by means of the spectroscope, in which it shows a yellow line at D 3. Recently it has been shown to be occluded in many minerals, often accompanied by H, and is also present in the gases of certain springs and to a very slight extent in the air. It is a very inert substance, and extremely difficult to liquefy.

HALOGENS.

This group is so called because they form salts (Greek, *hals*) directly with metals. Most of its members can be derived from sea-water and plants. Its members form binary salts by combining directly with metals. It includes four elements, two of which, Cl and F, are gases; Br, a liquid; and I, a solid. All are strongly electronegative, neutral, and generally univalent. They have a sharp, acrid taste, and a characteristic irritating odor; they corrode metals, combine with H to form colorless acid gases, and act as bleaching and disinfecting agents. Their relative combining energy is inversely to their atomic weights. They can all be prepared (except F) by removing H from their acids by means of O derived from MnO_2.

Experiment.—Drop a few grains of MnO_2 into three test-tubes. Then add to the first a little powdered NaCl, to the second NaBr, and to the third KI. Next pour into each a few drops of H_2SO_4 and warm. Note formation of Cl in the first tube, Br in the second, and I in the third. Cl and Br bleach moistened blue litmus-paper; I vapor reddens it.

Fluorin.—F was first isolated with electricity by Moissan in 1886. Its name is derived from the principal natural compound, fluorspar, CaF_2.

This element occurs very sparingly in a free state, but as CaF_2 it is found nearly everywhere. Cryolite ($NaFAl_2F_6$) is a porous rock abundant in Greenland. F is also present in sea and mineral waters, bones, teeth, and milk.

F is a colorless gas, so powerful in its affinities for other substances that it can be prepared only by electrolysis of HF in vessels of Pt or CaF_2. It is the only element that does not combine with O.

Chlorin.—This element was first prepared by Scheele in 1774, and was so named by Davy because of its greenish color. Cl never occurs free in Nature, but in combination with other elements it is of almost universal distribution.

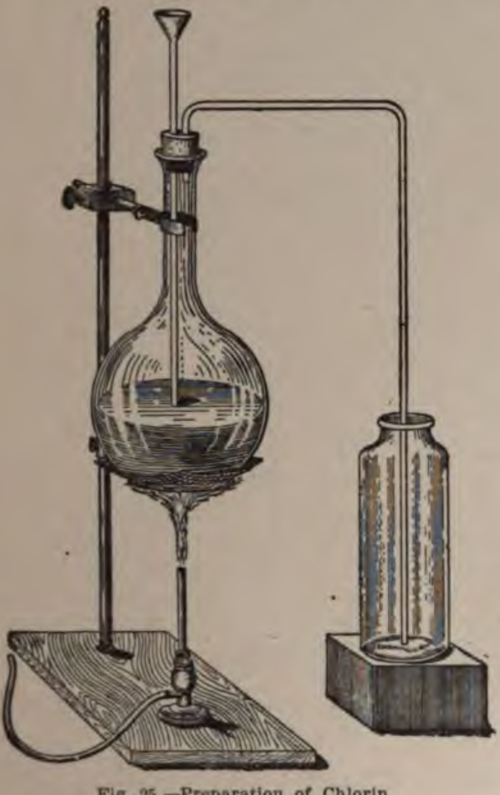


Fig. 25.—Preparation of Chlorin.

For laboratory or medical use it is usually prepared in one of the two ways indicated by the following equations:—

$$MnO_2 + 4HCl = 2H_2O + MnCl_2 + Cl_2$$
$$CaCl_2O + 2HCl = Cl_2 + CaCl_2 + H_2O$$

It will be noted in both instances that the H of HCl is oxidized and Cl set free.

Experiment.—Make and collect the gas dry (by downward displacement) and in H_2O.

Cl is a greenish-yellow gas of a peculiar, penetrating, suffocating odor and acid, astringent taste. It is 2½ times as heavy as air, and can be condensed to an oily liquid by 4 atmospheres at ordinary temperatures. One volume of water absorbs nearly 3 volumes of the gas. Aqua chlori, thus obtained, should contain not less than 0.4 per cent. by weight, of Cl. Cl water should be protected from air and light, as otherwise it changes to HCl.

Cl is highly electronegative; hence has affinity for most other elements, especially H and other metals. The gas prepared in daylight is much more active than that made in the dark.

Experiment. — Fill one test-tube with H and another with Cl. Place mouths of tubes together (Cl above) and hold in sunlight or near a flame. An explosion results.

H burns freely in Cl and Cl in H. This fact may be shown by holding a candle in a jar of Cl; the C of the candle is unburned and produces a dense cloud of smoke.

Experiment.—Throw a piece of paper wet with warm turpentine ($C_{10}H_{16}$) into Cl. Explain spontaneous combustion and dense smoke.

Experiment.—Show affinity of Cl for Sb by dropping some finely powdered Sb into a jar of the gas. It burns and is converted into a white powder: $SbCl_3$. This and the preceding experiment are best done with the gas freshly prepared by pouring HCl on $KClO_3$.

On account of its affinity for H, Cl acts as a bleacher (for cotton, linen, paper, and discolored teeth), deodorizer, and disinfectant: *i.e.*, freshly generated Cl unites with the H of H_2O and sets free nascent O, which is the really active agent in destroying colors, odors, or germs and their products. It is evident that these changes can take place only in the presence of moisture.

Experiment.—Show decolorizing action of Cl water on calico, and that the dry gas has little effect in this direction.

Cl tarnishes and corrodes all metals and is the solvent of Au and Pt in aqua regia. It discharges the color of common anilin inks.

Experiment.—Immerse a strip of Cu foil in Cl water, and note how quickly it blackens; also dip a knife-blade into solution of $HgCl_2$.

Bromin.—This element was first discovered by Balard in 1826, and owes its name to its strong odor. It occurs naturally only in combination with Mg and the alkali metals, accompanying the chlorids.

It is separated from the mother-liquor (bittern) of sea-water—from which NaCl has been removed by evaporation—and salt-wells and springs by treating the liquid with Cl. This element, being more negative than Br, has a greater affinity for metals, and drives Br from its metallic combinations, setting it free.

Experiment.—Shake KBr with Cl water and then chloroform, and note that the latter takes up free Br and is colored red.

Br is a dark-reddish-brown liquid, very volatile (fuming), and corrosive. It is 3 times as heavy as H_2O, in which it dissolves to the extent of 3 per cent.; it is more freely soluble in alcohol, ether, or chloroform.

Br is less energetic than Cl, but more so than I. Solutions of the element are decomposed by light, with formation of HBr. It stains organic matter yellow. Great care should be taken not to allow the fumes to corrode surgical instruments or the metallic parts of the microscope. If the hands get burned with the substance, NH_4HO ought to be applied at once. Though strongly germicidal, Br is seldom used as a disinfectant, because of its many disadvantages. Its chief use is in the manufacture of hypobromites.

Iodin.—I was discovered in 1811 by Courtois, a Parisian soap-boiler, in "kelp," or the ashes of sea-weeds. The name signifies violet.

I is found widely disseminated in the three kingdoms of Nature, though not abundant except in marine plants (especially laminaria), which absorb it from the sea-water, as do also the salt-water fishes, which accounts for the appreciable amount of I in codliver-oil.

I is prepared from sea-weed ashes (variously known according to locality as kelp, varec, and barilla) by lixiviation and evaporation to concentrate (crystallizing out $NaNO_3$), followed by the addition of H_2SO_4 to the mother-liquor (ppts. S), and finally distillation of the remaining clear liquid in the presence of MnO_2.

$$2KI + MnO_2 + 2H_2SO_4 = K_2SO_4 + MnSO_4 + 2H_2O + I_2$$

The product thus obtained is usually purified by resublimation. Much I is obtained as a by-product in the purification of crude saltpeter.

This element is met with in the form of brittle, neutral, volatile, crystalline, purple scales, with a distinct metallic luster and a peculiar odor and disagreeable taste. Its sp. gr. is nearly 5; m.p., 114°; b.p., 180°. It is very slightly soluble in H_2O, requiring for 1 part over 5000 of the latter. Its solution in H_2O is greatly aided by the presence of tannin or KI. Lugol's solution (liquor iodi comp.) is composed of 5 I and 10 KI in H_2O to make 100 parts. I is freely soluble in alcohol (tincture, 7-per-cent. strength), glycerin, ether, chloroform, and CS_2. The solution in alcohol is brown; in chloroform or CS_2, violet.

Experiment.—Heat I and notice beautiful violet vapor.

I is the least energetic of the halogens. It attacks some metals, however, to a marked degree; its solutions should not be handled in Ag spoons. It stains the skin brown. It is an irritant, an antiseptic, and a valuable alterative.

Test.—With hydrated starch I gives a blue color (amylum iodatum), showing as little as 1 part of I in 300,000. On heating, the blue color disappears, returning on cooling, if not all volatilized. The ordinary I tests fail in albuminous solutions, unless sufficient heat is used to coagulate the albumin.

I is used in medicine, in photography, and in the manufacture of iodids and some of the coal-tar colors.

Experiment.—To CS_2 add S and an aqueous solution of I, and note violet beads of SI_6. On adding KOH to this violet solution, covering with water and shaking, the color disappears, KI being formed.

OXYGEN.

This element was so named from a Greek word meaning sour or sharp, because it was formerly believed to be an essential element of all acids. It is the most abundant element in Nature, making up nearly ½ of the earth's crust. It occurs free as the active agent in air, of which it forms about ⅕. O constitutes by weight $\frac{8}{9}$ of H_2O, ½ of sand, and ⅓ of clay. It is a constituent of nearly all organic compounds, except hydrocarbons, and is found in combination in every part of plants and animals. It was discovered by Scheele in 1773.

O is usually prepared for experimental purposes by heating 4 parts $KClO_3$ at 200° with 1 part MnO_2.

$$2KClO_3 + MnO_2 = 2KCl + 3O_2 + MnO_2$$

Experiment.—Manufacture O in a copper retort, and collect over H_2O.

As seen by the equation, MnO_2 remains apparently unchanged. A reaction which is induced or aided by the mere presence of another substance is said to be catalytic in nature. Catalysis favors oxidation and other processes as lubricants aid the action of machinery. When the MnO_2 is not employed, a higher temperature (325°) is necessary. The presence of the Mn compound also makes the evolution of the gas more steady and regular. A pound of $KClO_3$ will yield 60 or 70 quarts of the gas. On a large scale O is manufactured by the Brin process, which consists in heating to 700° porous BaO in retorts into which pure air is forced. BaO_2 is formed, which gives off O on reduction of pressure.

O is a colorless, odorless, tasteless gas a little heavier than air: a liter weighs 1.43 gm. It is difficultly liquefied, requiring a pressure of 300 atmospheres and a reduction of temperature to — 140°, when it condenses into a transparent liquid, a little lighter than H_2O. The critic temperature of O is — 120°. It dissolves in H_2O to the extent of 3 per cent. by volume, and it is from this source that aquatic plants and animals obtain the O necessary to their existence. O is the most magnetic of all gases.

O unites with every element except F (not directly with Au, Pt, and Ag), forming oxids and oxysalts. This union is termed oxidation, or "slow combustion," unless light as well as heat results, when the process is known as combustion. Substances readily oxidized are said to be combustible and are composed mainly of C and H, the C being converted into CO_2, and H into H_2O. The CO_2 and H_2O given off by the lungs and urea by the kidneys are produced by oxidation in the tissues. Plants take up this CO_2 in sunlight, keep C, and set free O. Artificial heat, light, and mechanic energy are produced mainly by oxidation.

Experiment.—With a glowing match show that O is a supporter of combustion, but not combustible.

Some substances burn in O that will not burn in air.

Experiment.—Burn a watch-spring in O, after attaching to one end a match by spiral turns.

Combustible substances and supporters of combustion are relative terms, since the union of two such substances is mutual. Air or O can be made to burn in illuminating-gas by a simple device consisting of a lamp-chimney with a bottom cork through which two glass tubes pass, one to admit air, the other illuminating-gas. When the gas is passed in freely, the flame leaves this tube and goes to the air-tube.

O is the chemic source of heat, energy, and life for both plants and animals. About two pounds daily are used up by an adult person in this way. Plants use less O than animals, having less energy, and set free a great deal more than they consume. Animals require a large amount of O, giving off CO_2 in return. The principal subjective effect when pure O is inhaled is a sensation of warmth in the upper respiratory tract. O is Nature's great antiseptic, purifying the air, water, and soil by destroying the germs of disease and their chemic products. The sap of plants requires O to elaborate and render nourishing.

O is used largely in respiratory or circulatory affections with deficient oxygenation of the blood. It is also administered by inhalation for dangerous chloroform narcosis and poisoning by coal-gas and other noxious vapors. In chronic cases 1 to 5 gallons is a dose.

Ozone.—This peculiar allotropic form of O exists in the atmosphere in comparatively small quantities: about 1 part in a million. It is generated by heat, light, evaporation, and electricity; slow oxidation, rapid combustion. It is most abundant at high altitudes, in country places, after thunder-storms, in the spring-time, and in the neighborhood of plants. It is produced artificially by the action on air of a high-tension current of electricity without sparking. Ozone is triatomic. It may be condensed into a blue liquid. It is soluble in turpentine or ether, and breaks up into O_2 and O at 237°. Like H_2O_2, it tarnishes metals and corrodes cork and rubber. It is used as a bleaching agent, for purifying drinking water and for "aging" liquors. The word ozone is of Greek origin, and signifies "I smell" (1 part in 100,000 recognized by odor). The characteristic irritating odor of the substance may be elicited by dipping a strongly-heated glass rod into vapor of ether, or by mixing H_2SO_4 with $KMnO_4$ solution, or around medical batteries or X-ray machines.

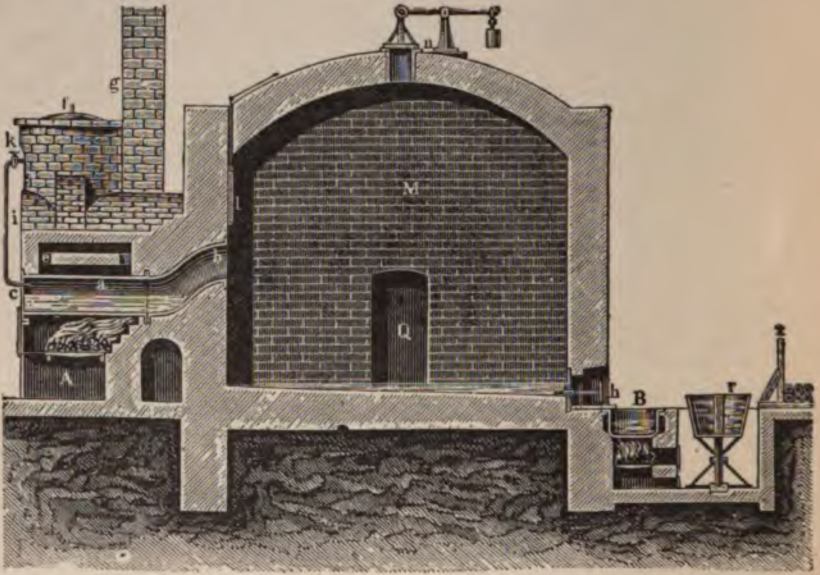


Fig. 26.—Sublimation of Sulphur.

Experiment.—A simple test for ozone is hanging a piece of starch-paper impregnated with KI over a piece of P, freshly scraped and partly covered with H_2O. Ozone, being more negative than I, displaces the latter, producing a blue color with the starch.

SULPHUR.

This element has been known from the earliest times. In a free state, mixed with earthy matters, it is found most abundantly in the vicinity of active and extinct volcanoes, having been formed by the following reaction:—

$$2SO_2 + 4H_2S = 4H_2O + 3S_2$$

In combination it is almost universal in the sulphids of the metals, and is also of common occurrence in the H_2S of mineral waters, the sulphates of the alkalies and alkaline earths, and in animal and vegetable compounds.

About a third of the S of commerce is derived from sulphid ores. The remainder comes from volcanic regions, especially Sicily and other Mediterranean countries, which furnish annually 100,000 tons. A great deal is obtained from Iceland, Mexico, Central America, the Sandwich Islands, and—in this country—Santa Barbara, Cal., and Cove Springs, Utah. It is also a considerable by-product in the manufacture of coal-gas, from the iron pyrites in the coal.

S is separated from accompanying impurities (2 or 3 per cent.) by melting along with a little fuel in furnaces with inclined grooved bottoms, where the S solidifies into rolls; hence the name roll sulphur for brimstone (burnstone). It is further purified by sublimation, the vapors condensing in a cooler chamber into sublimed S, or flowers of S.

Ordinary S is a lemon-yellow, odorless, nearly tasteless, brittle, crystalline solid (rhombic octahedra or monoclinic). It is insoluble in all the ordinary solvents except benzin, turpentine, chloroform, fixed oils, and CS_2 ($^{100}/_{37}$). The sp. gr. of S is about 2; its m.p., 114½°; b.p., 448°. Melted S allowed to cool slowly assumes a prismatic form. When melted it is a thin, yellow liquid, becoming thick and brown at 250°, turning lighter again at 330°. Melted S at about 400°, poured into H_2O, forms an amber-colored, elastic, tenacious mass termed plastic S. This variety is amorphous, and not soluble in CS_2.

Experiment.—Make plastic S by melting S in covered vessel and pouring into H_2O.

S is generally electronegative, and in ternary compounds may take the place of O as a linking agent. Its vapor density below 500° is 96; between 800° and 1000°, 32. At ordinary temperatures S oxidizes slowly, forming H_2SO_3 and H_2SO_4. It burns with a blue flame at 230°, forming SO_2. S combines with most metals and with many metalloids. Physiologically S is innocuous.

Sublimed S is used largely as a vulcanizing material. For dental rubbers caoutchouc is heated till soft, then ground with half as much S and with coloring matter usually, and subjected to heat (320° F.), pressure, and moisture for an hour. S is employed extensively in the manufacture of gunpowder and matches. Medicinally it is serviceable as a laxative (in compound licorice-powder) and in parasiticide ointments; the latter action is attributed to the SO_2 present in sublimed S. Sulphur is changed (by Na_2CO_3) in the bowel to H_2S and sulphids, which cause increased peristalsis, reduce oxyhemoglobin and depress the central nervous system.

The official forms comprise: 1. S sublimatum (ordinary S). 2. S lotum, or washed S, from which the acid gases have been removed with NH_4HO. 3. S præcipitatum, or lac or milk S, a whitish, amorphous powder prepared by the successive action on S of lime and dilute HCl. 4. Unguentum sulphuris, which contains 15 per cent. of S sublimatum.

SELENIUM.

This element is widely distributed, though in small quantities, usually associated with S. It appears as an amorphous, brick-red powder, soluble in CS_2; and as a crystalline, dark-gray solid, insoluble in CS_2. The element burns with a bright-blue flame and an odor like that of horse-radish.

TELLURIUM.

This rare element is found free or combined as tellurids with Au, Ag, and other metals. It resembles metals in being solid and silver-white. It burns in the air with a blue flame tinged with green. Tellurids are recognized by fusing with K_2CO_3. The resulting K_2Te dissolves in H_2O with a red color, and on adding HCl yields a garlicky stench of H_2Te.

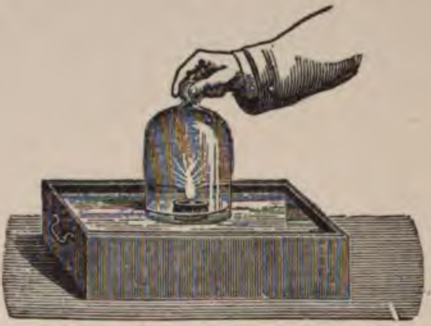


Fig. 27.—Preparation of Nitrogen.

NITROGEN, OR AZOTE.

This element was first discovered by Rutherford in 1772. It was so named because it is an essential element of niter, or saltpeter. Free N constitutes about four-fifths of the atmosphere. In combination it is the characteristic element of nearly all animal substances and their decomposition products, ammonia, nitrates, nitrites, and cyanids. It is also present in a number of vegetable compounds.

Experiment.—Burn P on a cork on water under a bell jar. The O is removed, forming dense, white fumes of P_2O_5, which is absorbed by the water, and N is left.

Pure N is prepared by heating NH_4NO_2 in a glass retort, or KNO_2 and NH_4Cl.

N is a colorless, odorless gas, a little lighter than air. It liquefies at — 130° under a pressure of 280 atmospheres. One and a half volumes of the gas dissolve in 100 of water.

N is neither combustible nor a supporter of combustion.

Experiment.—Raise lighted candle into jar of N.

N is chemically inert and has little affinity for other elements, except Mg, B, V, and Ti. Its compounds are therefore unstable, decomposition often taking place with explosive violence. The passive nature of N accounts for the active and dangerous character of its compounds, such as nitroglycerin and nitrates, as well, perhaps, for the physiologic potency of the cyanids, alkaloids, and other nitrogenous products.

N gas, though non-poisonous, is not directly utilized by the system. Its presence in inhaled air is needed to prevent too rapid oxidation of the tissues. N is occasionally employed as a medium for chemic processes from which O must be excluded.

THE AIR.

Until 1772 air was considered to be an element. Air is a mechanic mixture, and not a compound. This is proved by the facts that its constitution is not absolute, that when absorbed by H_2O the N and O are not in the same proportion as in the atmosphere, and that there are no chemic phenomena on mixing N and O. The principal gases in air are O and N, in the proportion, by weight, of 23 per cent. of the former and 76 per cent. of the latter; by volume, 20.61 per cent. of O and 77.95 per cent. of N. Argon constitutes 0.63 per cent. of the atmosphere, and was discovered by Rayleigh and Ramsey in 1894 by removing from air both the O (with red-hot Cu turnings) and the N (with red-hot Mg) as well as H_2O and CO_2. Argon is the most inert element known, and its name signifies no energy. Helium is another gas lately discovered in our atmosphere (1 to 10,000), and already noticed in the solar spectrum; hence its name. Coronium is another atmospheric gas, found in volcanic vapors, and showing a characteristic green line in the solar spectrum. There are also traces of hydrogen, neon (new), krypton (hidden) and xenon (strange).

Experiment.—Estimate the amount of O in air by exposing a measured volume of air in a graduated tube over Hg, to the action of a strong solution of potassium pyrogallate, noting diminution of volume at end of an hour.

Water-vapor is present in air to the extent of 0.75 to 1.5 per cent. (3 to 16 volumes per 1000). CO_2 in the atmosphere should not exceed 4 parts in 10,000. All solid substances condense upon their outer and inner surfaces the gases of the atmosphere, particularly on cooling, as in the case of a Pt crucible.

The porosity, or pore-volume, of ordinary soils is about 40 per cent.—sandstone, as much as 30 per cent. The permeability to air depends, not on pore-volume, but on the size of the individual spaces, and varies conversely with the degree of contained moisture in the soil.

Liquid air is now made on a commercial scale by machinery. The air is subjected to a pressure of a ton to the square inch, and at the same time allowed to escape through a very fine orifice, cold water being used to cool the air before expansion. Much heat is absorbed in expansion, and by repeating the operation three times the temperature is lowered to or below — 191°, at which point liquefaction takes place. Liquid air is faintly blue. In open vessels it evaporates rapidly; the N, being somewhat more volatile, is given off more rapidly than O. Even at this temperature the O residue is an energetic supporter of combustion, burning and melting Fe (1400°). Soft and elastic organic substances and metals become very brittle when immersed in this fluid. Liquid air has been used to some extent in medicine as a caustic application: *e.g.*, in lupus. As a local anesthetic its effect lasts 30 to 40 minutes. Liquid air has been preserved for weeks in Dewar bulbs surrounded by a vacuum (contains no moisture).

PHOSPHORUS.

The word phosphorus means the light-bearer and indicates the combustible nature of this element. P was discovered in 1669 by the German alchemist Brandt, by distilling urine with sand.

This element does not occur free in Nature. It was primarily combined with O in the ancient rocks, which on disintegration furnished P for plants, and these to animals. The principal natural compound is rock phosphate, $Ca_3(PO_4)_2$, which is made up largely of the bones of prehistoric animals. It is found in veins in the rocks of certain regions, especially near Charleston and Memphis, and is also present in small amounts everywhere.

P is prepared by treating bone-ashes or the mineral sombrerite (impure $Ca_3[PO_4]_2$) with an equal volume of 50 per cent. H_2SO_4, yielding $CaSO_4$ and $CaH_4(PO_4)_2$. The latter salt on heating to redness loses two molecules of H_2O, and is thereby changed into the metaphosphate, $Ca(PO_3)_2$, which is, in part, reduced to P by charcoal with the aid of a white heat or by distilling with sand. The crude P thus obtained is purified by redistillation, and is allowed to solidify in molds of glass or Cu.

This element has four allotropic forms; two white, a red, and a black. The ordinary stick, or white, octahedral P is of a translucent, waxy appearance; sp. gr., 1.83; m.p., 44°. It can be cut with a knife, and has a characteristic odor. It is insoluble in H_2O, slightly soluble in ether and in alcohol (1 to 350), and quite soluble in chloroform. The best practicable solvents for it are fixed oils (1 to 50), though CS_2 is most efficient, dissolving 20 times its own weight of P, the solution being spontaneously inflammable on exposure to the air.

Red, or "amorphous," P is prepared by heating the ordinary variety at 300° in a closed iron vessel filled with N or CO_2. It is generally insoluble, not so inflammable as the white variety, and has a sp. gr. of 2.14. It is reconverted into ordinary P on heating to 280°. The third variety—called black, or metallic, P—appears in the form of dark-red, rhombohedral crystals; sp. gr., 2.34. It is made by heating waxy P along with Pb at a little below red heat in sealed tubes for 10 or 12 hours, after which the Pb is dissolved out with dilute HNO_3. A fourth variety, white and flaky, is prepared by distilling ordinary P in an atmosphere of H.

Ordinary P is very oxidizable, igniting spontaneously in air at from 50° to 60°. At lower temperatures it oxidizes more slowly, with phosphorescence. To prevent spontaneous combustion, it is kept under H_2O. When partly exposed to the air it evolves white fumes of P_2O_5, and also ozone and H_2O_2. P combines directly with all the common elements except C, H, and N. Red P is much more inert than the white, not igniting below 260°. The black variety is the least active.

Experiment.—Make fire under water by placing in a conic glass of H_2O a few bits of P and some crystals of $KClO_3$, adding to these by means of a pipet some H_2SO_4.

Phosphin, H_3P, is a colorless gas with an odor like garlic, formed in Nature by the putrefaction of organic substances under water. When mixed with PH_2 (a liquid) it is spontaneously combustible. This is the *ignis fatuus,* or will-o'-the-wisp, of marshy places.

Experiment.—Make H_3P by boiling P with KHO, first expelling air in the flask by dropping in a few drops of ether. Keep the beak of the retort under water, and note how the bubbles ignite as they appear at the surface and the curious rings of P_2O_5 that are formed.

P and its compounds are used extensively in medicine for building up the bony and nervous tissues. P is usually given in a pill-mass with cacao-butter and coated with sugar or gelatin. P matches are made by dipping the wooden slips tipped with paraffin or S in a mixture of glue and P, to which have been added other ingredients—such as MnO_2, KNO_3, chalk, S, lamp-black and other oxidizers, combustibles, and hard substances—to increase friction. Parlor-matches crackle because of the quick combustion, due largely to $KClO_3$. Safety-matches contain no P, but Sb_2S_3, Pb_3O_4, and $KClO_3$, or $K_2Cr_2O_7$. In order to ignite them they must be rubbed on a surface composed of red P and Sb_2S_5. The gritty nature of the latter compound makes the friction greater. Red P is slightly, if at all, toxic, and is used in Europe for making matches, in place of the white variety, which is still employed almost exclusively in this country.

A simple test for P is to heat in a test-tube with acidulated water, and note the phosphorescence. Filter-paper dipped in $AgNO_3$, held above the mouth of the tube, is colored dark by formation of silver phosphid.

BORON.

This element was first isolated by Davy in 1808. The name is derived from an Arabic word meaning to shine, and referring to the incrusted shores of borax lakes. It is found in the natural state only in combination, chiefly as borax and boric acid.

B appears as a brown or yellow, amorphous powder, graphitoidal scales, or octahedral crystals. These crystals are infusible and next to the diamond in hardness, and have a sp. gr. of 2.68. At high temperatures B combines directly with N.

SILICON, OR SILICIUM.

This element was so called from the Latin word *silex,* meaning flint. It was first isolated by Berzelius in 1823.

Next to O, Si is the most abundant element in Nature. It is never found free. It is the chief constituent of nearly all rocks and soils, and is present in plant-ashes and to a much less extent in animal tissues.

Si may be prepared by heating together K_2SiF_6 and K_4. When thus obtained it appears as dark, lustrous octahedra, hard enough to scratch glass, and with a sp. gr. of 2.5. It may also be procured in amorphous and graphitic forms corresponding with those of C.

CARBON.

C in all its forms was known to the ancients. Its name is derived from *carbo*: Latin for charcoal.

C is found in Nature in three allotropic forms: two crystalline (diamond and graphite), one amorphous, including coal (90 per cent. C, 3 to 6 per cent. H, and O and N), charcoal, coke, lamp-black, and gas-retort carbon. The diamond is the hardest substance known. It is 3½ times as heavy as H_2O, and crystallizes in cubes or octahedra. Its brilliancy depends on internal reflection of light, owing to its great refractive power. The best diamonds are found in the gravel-beds of Brazil and South Africa. These are worn as gems; small and imperfect ones are used in glass-cutters, miners' drills, and rock-boring machines. Microscopic diamonds are found in steel made by the Bessemer process. The carat, or special unit of weight for diamonds, is equal to 3.17 grains. Real diamonds glow in the dark when exposed to radium rays, and shine under water.

Graphite (plumbago, black lead) crystallizes in unctuous hexagonal prisms; sp. gr., 2; is almost infusible, and is a good conductor of electricity. On account of its non-oxidizability, this substance is much used as a protective and lubricant: *e.g.*, in stove-polish and for machinery and bicycle-chains. It is also used in painting metals, electrotyping, glazing, gunpowder, as a mold-wash, and mixed with clay and sand in crucibles. It owes the name graphite to the use which is made of it in pencils. Graphite is deposited (gray cast iron) from molten cast iron when in excess of 2 per cent. and is made from charcoal in the electric furnace.

All the amorphous varieties of C are derived by natural or artificial incomplete combustion of the vegetable growth of the past or the present. Coal, for example, is the product of the changes effected in the forests of long ago by great pressure and terrestrial heat (due to changes in the earth's crust) without access of air, driving out more or less the liquids and gases of the trees and other plants from which the coal was formed. The gases formed are chiefly CO_2 and CH_4 (methane). According to the relative completeness of carbonization, there are several kinds of coal. Anthracite, or "hard," coal contains hardly any volatile products; hence on burning it glows, but does not yield a flame. Bituminous, or "soft," coal, on the other hand, has not undergone so much pressure. It is rich in petroleum (from which coal-oil is made) and in gaseous compounds; hence it burns with flame, or, if heated in suitable retorts in the absence of O, the gases may be separated from the solid coal and be utilized as illuminating gas or for heating purposes. The residue of solid coal left in the retorts is termed "still coke," gas-carbon, or plumbagin. It is hard, compact, and difficult to fuse, and is much used for electrodes and battery-plates. Cannel-coal is a compact subvariety of bituminous, and was so named because on combustion it gives a steady light like that of a candle. Lignite, brown, and wood coal, as the names indicate, are soft coals nearer to the woody nature of the coal-forming plants than is ordinary bituminous coal. They are most abundant in the Rocky Mountain regions. Jet is a peculiar kind of coal, so called because it is capable of taking a fine polish. Peat is a carbonaceous fuel made up of partly-carbonized vegetation mixed with mud. It is obtained in great quantities from the boggy districts of Ireland.

Wood-charcoal (carbo ligni) is made from piles of wood (U. S. P., soft willow-twigs) by burning the latter with little air: that is, covered with earth. The wood consumed yields about ⅕ its weight of charcoal. Carbo ligni is a light, porous powder, noted for absorbing gases—90 volumes of NH_3 at ordinary temperatures, or about twice as much at f.p. Because of this property, wood-charcoal is much employed as a deodorizer to occlude H_2S and other foul gases. It is also used internally for the same reason, in fermentative digestive disorders and as an antidote for poisons. The antiseptic power of charcoal is very slight. Wood-charcoal is employed as a fuel in metallurgy and in the manufacture of crucible and cementation steel.

Experiment.—Introduce a piece of heated charcoal into a test-tube previously filled with NH_3 over Hg, and note rise of the metal, owing to absorption of the gas.

Animal charcoal (bone-black, ivory-black, carbo animalis) is prepared by the destructive distillation of bones in much the same manner as the ligneous variety is obtained. The crude product is purified by treating with dilute HCl, which dissolves out any $Ca_3(PO_4)_2$. Bone-charcoal is employed largely for decolorizing sugar and purifying petroleum, and also in boot-blacking and along with sand in water-filters. Carbonized blood is similar to bone-black, and is used for the same purposes.

Coke is obtained from coal much in the same way as charcoal is from wood. It burns, of course, without flame, but furnishes a steady, intense heat.

Lamp-black is the collected smoke of burning tar, rosin, turpentine, or petroleum, with a limited supply of air. It is identic with the soot of chimneys and lamp-chimneys, and has wide use in black paints and printers' ink. Certain woods, as piñon, are much richer in carbonaceous resins than others, and hence soon fill up a chimney with soot.

Experiment.—Burn camphor or turpentine in a wide-mouth bottle and notice lamp-black formed. India ink is made by burning camphor.

Free C in any form is soluble only in molten cast iron, forming a binary compound, called carbid, with the metal. A part, however, usually crystallizes out as graphite on cooling. C is fused and volatilized only by the electric arc light. It is not oxidized at ordinary temperatures, but at high ones has a great affinity for O. Hence in the form of fuel it is much used as a reducing agent in smelting and as charcoal supports in assaying. C unites directly with very few elements, indirectly with a great many. In combination C is present in all plants and animals, in most combustibles, and in fats, oils, and carbonates.

OXIDS.

This class of compounds may be divided into neutral (water), basic, and acid oxids.

Water, H_2O, is the most abundant compound in Nature. It constitutes 65 or 70 per cent., by weight, of the human body, and is present in large amounts in both plants and animals, and also in most minerals as water of crystallization. Like air, it was thought to be an element until decomposed with electricity by Lavoisier in 1783. It occurs in Nature in three forms, being solid below 0°, gaseous above 100° (at sea-level), and liquid between these temperatures.

Experiment.—Prove that dry wood contains H_2O by heating a match stick in a glass tube sealed at one end.

Water is composed of H and O, 2 volumes of the former to 1 of the latter, the 3 volumes becoming condensed to 2; or, by weight, 8 parts of O to 1 of H. The molecular weight of H_2O is 18; density of water-vapor, 9.

Experiment.—Decompose H_2O by electrolysis, and prove identity of gases. A little acid hastens the process.

Water is produced in four ways: 1. By direct union of H and O through the agency of electricity in a eudiometer or by burning H in air. 2. By oxidation or combustion of substances containing H. One to two pounds of H_2O are formed daily in the human body in this way. 3. By the action of an acid on a base or metallic oxid. 4. In the reduction of a metallic oxid by H.

Pure H_2O is a colorless, tasteless, odorless, transparent, mobile liquid. In large quantities it appears blue or green. It is 773 times as heavy as air. The greatest density of water is at 4° C., at which point it is taken as the standard of specific gravity. Below this temperature, as well as above, it becomes lighter, expanding one-eleventh in changing to ice. It is the most universal solvent, and hence is never found absolutely pure unless distilled. It is a poor conductor of heat and electricity, though better than air. The temporary hardness of water is due to calcium and magnesium bicarbonates, which on heating give off CO_2 with precipitation of less soluble neutral carbonates. Permanent hardness, which persists after boiling, depends on the presence of $CaSO_4$ and $MgSO_4$.

The f.p. of H_2O is raised by anything, as rise in altitude, which diminishes pressure; and the same circumstances have the effect of lowering the b.p. Conversely, the b.p. under a pressure of 25 atmospheres is 224°. The presence of salts in solution lowers the f.p. and raises the b.p. When water freezes it forms hexagonal crystals, best seen in the form of snowflakes; slight agitation favors the process of congelation. When water vaporizes it expands to 1700 times the former volume; hence the power of steam. The great superiority of steam-sterilization over hot-air depends on the great amount of latent heat in steam.

Water is a very stable compound, dissociation not taking place under 1000°. It is neutral in reaction, and is therefore used very largely as a solvent for medicines and chemic reagents. It unites, however, with metallic oxids to form bases or hydroxids, and with negative oxids to form acids, and is decomposed by a few of the most positive metals with evolution of H.

Experiment.—Show that CO_2 and H_2O make an acid.
Experiment.—Show that CaO and H_2O make a base.

Deliquescent substances, those which are very soluble in H_2O and take it from the air to be dissolved in, are used in the drying of gases and precipitates. Examples of such drying agents are $CaCl_2$, H_2SO_4, and P_2O_5. The water of crystallization of minerals is held in place by a feeble chemic union (hydration) with the salt proper of the substance, and is readily separated by heating at 100° to 120°, or, in the case of efflorescent substances especially, by simple exposure to the air. Many medicinal mineral salts contain a large proportion of water of crystallization.

Water has three phases: ice, water, vapor; the vapor tension of vapor being the greatest. Equilibrium depends on pressure, temperature and concentration of components. At 4.6 mm. pressure and 0° the three phases of water are in equilibrium. An invariant system is one in which the number of phases exceeds the components by two, and any variation of conditions destroys equilibrium. Water and vapor are a univariant system, since the number of phases exceeds the components by one. Vapor, water or ice alone forms a divariant system, having two degrees of freedom, the phases and components being equal in number. Either temperature or pressure can be changed without destroying equilibrium within a certain area. The critic temperature or pressure is that above or below which water cannot exist as a liquid.

Water is of more immediate necessity to the system than is solid food. It serves in the body to assist in processes of solution, secretion, excretion, circulation, and the regulation of heat by evaporation. Five or 6 pints daily should be taken by adults in food and drink.

The official forms of water are as follows: Aqua is the Latin name for natural water. Aqua destillata is prepared by distilling 1000 parts of pure natural water, the first and the last 100 parts being rejected in order to prevent contamination, in the first place with gases, and at the end of the process with solid matters. The preparations called aquæ are solutions in distilled H_2O of a gaseous or volatile substance. Those made from the volatile oils (peppermint, anise, etc.) contain 1 minim of the oil to each ounce of the solvent, solution being accomplished with the aid of talc. Liquors are aqueous solutions of fixed and solid bodies: *e.g.*, liquor potassæ, liquor calcis. Decoctions are aqueous solutions of vegetable substances, prepared by placing the given substance in boiling water for ten or fifteen minutes. Infusions are vegetable solutions made with water at a temperature below the b.p. By maceration in chemistry is understood the continued action on a substance of H_2O at ordinary temperatures; when such extraction of medicinal agents is made with boiling H_2O, the process is termed digestion. The separation of an alkali salt from its insoluble impurities is called lixiviation; leaching ashes is a common example.

METALLIC, OR BASIC, OXIDS.

These are solid substances obtained by burning the metal in air or heating its hydroxid or carbonate. They are all insoluble as such in water, but dissolve in acids without effervescence, forming salts. Oxids of the alkalies and alkaline earths combine with H_2O to form hydroxids, which are more or less soluble. Oxids (not MgO or Al_2O_3) are reduced by heating with powdered charcoal or by passing a current of dry H over them when heated to redness. Peroxids are ready oxidizing agents. Lower oxids are termed oxyduls.

Identification of Oxids.—Mainly by negative reactions. No change when heated alone, except HgO (volatilizes and separates into elements) and AgO, Au_2O_3 and PtO_2 (leave metal).

After dissolving in an acid and removing metal with H_2S or Na_2CO_3, no acid radical is found except that of solvent. Boiling or fusion with alkalies is also negative.

Peroxids give off O when strongly heated, and evolve Cl when heated with HCl.

Potassium.—This metal has three oxids, the monoxid, K_2O; peroxid, KO_2; and suboxid, K_4O. The first is a white powder obtained by heating the metal in dry air. It becomes red hot when moistened with H_2O. The second is a yellow mass obtained by heating the metal in excess of O. When the metal is burned in insufficient air an unstable blue compound, K_4O, is formed.

Sodium.—The monoxid, Na_2O, is a gray mass combining violently with H_2O. The peroxid, Na_2O_2, is a very caustic, light-yellow powder, used as an oxidizing and bleaching agent. On mixing with H_2O it yields about 20 per cent. of O.

$$Na_2O_2 + H_2O = 2NaHO + O$$

Lithium.—Li_2O is a white crystalline mass uniting with H_2O to form $LiHO$.

Calcium.—CaO (lime, quicklime, calx) is obtained by burning limestone with alternate layers of fuel in a kiln.

$$CaCO_3 = CaO + CO_2$$

It is a gray-white, infusible solid, with a sharp, caustic, alkaline taste. It is a good drying agent, and is used in many industries. In the oxyhydrogen flame a stick of lime produces the intensely white Drummond, or calcium, light. On exposure to the air lime slakes: that is, becomes converted into a mixture of hydrate and carbonate by absorption of H_2O and CO_2.

Strontium.—SrO is a gray-white powder used in sugar manufacture. SrO_2 appears as a light, white powder.

Barium.—BaO is a light-gray, porous mass used in the manufacture of O. BaO_2 is a light-gray or yellowish, coarse powder used for the preparation of H_2O_2.

Magnesium.—Magnesia, MgO, is prepared on a large scale by calcining at a red heat the carbonate, the light (calcined) or heavy (ponderosa) variety being formed according as the light or heavy carbonate is used. Heavy MgO is also made by rubbing the light variety in the presence of alcohol. Compact magnesia is made by heating the nitrate or chlorid just to bright redness. MgO is a loose, white powder of an earthy taste. The official light magnesia is 3½ times as bulky as the same weight of heavy magnesia. MgO is used as a face-powder, an antacid laxative, and an antidote for arsenic and corrosive acids. It is nearly insoluble in H_2O, with which it forms the hydrate, which is dissolved by NH_4Cl (used to separate Mg from Ca). A mixture of compact MgO, H_2O, and chalk or marble-dust is used as a filling for decayed teeth.

Zinc.—ZnO is a white, floury powder much used in astringent ointments and also in paints; it does not darken with H_2S. It turns yellow on heating. It is used as a source of other Zn compounds. The purest ZnO is made by igniting the carbonate.

Dental cements are made with dehydrated ZnO as a basis and a liquid. The cement commonly employed is oxyphosphate, a solution of ZnO in pure glacial phosphoric acid. Oxychlorid cement consists chiefly of ZnO and a solution of $ZnCl_2$ (sp. gr., 1.5); oxysulphate, of ZnO and $ZnSO_4$ in powder and $ZnCl_2$ solution, or solution of gum arabic and a little $CaSO_3$. The powder and liquid are mixed thoroughly on glass or porcelain with a stiff spatula until a putty-like, elastic, non-adhesive mass is produced. Silica, borax, and ground glass are often added to make "set" mass harder and less contractile. The various shades of color, from light cream to dark yellow, are secured by proper manipulation of the heat in calcining the ZnO: dark yellow requires a white heat for two hours. Dental cements are broken up by either alkalies or acids. Oxyphosphate is the most durable cement. The oxychlorid is irritant, but somewhat antiseptic, and is used for lining cavities prior to filling. Oxysulphate is non-irritant, but deficient in hardness, and is used for protecting pulps. All cements are more or less porous. Porcelain cuttings for dental cavities are put in with cements.

Experiment. Oxyphosphate Cement.—To prepare powder weigh out 45 gm. of crude ZnO, moisten with HNO_3, and apply gentle heat, constantly stirring with glass rod until brown fumes cease. Then transfer powder to clean clay crucible and apply white heat in furnace for an hour or two. Remove from furnace, pulverize in mortar, sift through fine cloth, and bottle in three equal parts. To prepare liquid add a few pieces of glacial phosphoric acid to 10 or 15 c.c. of distilled H_2O in test-tube; heat gently from time to time, adding more acid till liquid is like glycerin in consistence; then filter and bottle. To make the cement pour liquid and solid near each other on mixing plate, adding the powder little by little to the liquid and spatulating until a homogeneous mass is obtained.

Experiment. Oxychlorid Cement.—To 10 gm. of calcined ZnO add and mix thoroughly 0.1 gm. of borax and 0.2 gm. of silica. Calcine in clay crucible in furnace at bright-red heat for a half-hour or more; then remove, pulverize, sift and bottle. For the liquid portion dissolve granular Zn piece by piece in 10 c.c. of HCl, and heat gently till acid is saturated; then filter through glass wool and preserve in well-stoppered bottle. The mixing process is the same as for oxyphosphate.

Experiment. Oxysulphate Cement.—Mix 10 gm. of calcined ZnO with 4 gm. of dry $ZnSO_4$. Place mixture in clay crucible and calcine in furnace as for oxychlorid; then pulverize, sift, and bottle. The liquid portion is obtained by dissolving 2 gm. of $ZnCl_2$ in 10 c.c. of H_2O. In mixing the two portions the powder is added only until a cream-like mass is obtained.

Copper.—The cuprous compound, Cu_2O, is a red powder, soluble in NH_4HO. It is used to give a red color to glass. Cupric oxid, CuO, is an amorphous, dark-brown or yellow powder, soluble in NH_4HO. In the presence of organic substances it gives up O readily, and is much employed in organic analysis. It is also the coloring matter in artificial emeralds. CuO forms with H_3PO_4 a hard and tenacious black mass sometimes used as a filling for teeth.

Experiment.—Heat in a hard tube a pinch of sugar with about ten times as much CuO until a coppery residue shows reduction.

Mercury.—Hg_2O is a dark-brown powder used in medicine as "black wash," made by the reaction between calomel and lime water, 4 grains to the ounce.

$$Hg_2Cl_2 + Ca(HO)_2 = Hg_2O + CaCl_2 + H_2O$$

Both oxids are used extensively in medicine.

Experiment.—Make lotio nigra and lotio flava as above described.

Aluminum.—Al_2O_3, or alumina, is found native in hard crystalline minerals, and is made commercially from bauxite by the action of H_2SO_4, or of Na_2CO_3. It is a light, white, odorless, and tasteless powder, little acted on by acids or alkalies.

Tin.—SnO is a brown or white powder. SnO_2 is a fine, white or buff powder, used as a polishing agent under the name of putty powder.

Lead.—The suboxid, Pb_2O, is a soft, black powder. The official monoxid is in two varieties: massicot, prepared by heating the carbonate or hydrate to low redness, and litharge, a by-product in desilvering lead-ores. Both are yellowish, but litharge is more inclined to red. They saponify fixed oils and fats. Litharge has extensive use in the manufacture of flint glass, in drying paints, glazing earthenware, and sweetening liquors, in lead plasters, and as the chief source of other Pb salts. The sesquioxid, Pb_2O_3, is also a reddish-yellow powder. Red lead, minium, Pb_3O_4, is obtained by carefully heating (at 300°) litharge. It is used as a pigment and in flint glass and cements. The peroxid or puce oxid, PbO_2, is a chocolate-brown powder used as an oxidizer and left as a residue from red lead when this is heated with HNO_3. Oxids of Pb are sometimes used to color artificial teeth.

Experiment.—Prove double composition of red lead by adding to a little in a test tube 6 times its volume of dilute HNO_3. PbO is dissolved, leaving a dark-brown residue of PbO_2.

Bismuth.—The only oxid of interest is Bi_2O_3, a yellow, fusible powder, prepared by roasting other salts of Bi. It is employed in making opera-glasses, for which purpose it surpasses Pb.

Chromium.—CrO_3 ("chromic acid") appears in brown-red needles, blackening temporarily on heating. On account of its great avidity for H_2O, it is escharotic, and is used in 1-per-cent. solution as a hardening agent. It is an energetic laboratory oxidizer, and hence should never be prescribed with oxidizable substances.

Experiment.—Pour absolute alcohol on a few crystals of CrO_3, or lay a crystal of CrO_3 on a pledget of cotton moistened with absolute alcohol. Spontaneous ignition takes place—more rapidly when warmed.

Cr_2O_3 (chromic oxid) is a dark-green powder used for coloring glass, porcelain, enamels, and artificial teeth (modifies yellow of TiO_2).

Manganese.—MnO_2, the black oxid, is used in the laboratory in the preparation of O and Cl. It imparts an amethyst or purple color to glass and dental frit, and is utilized to remove by oxidation the green color (due to iron-sand) of common glass. MnO_2 is added to clay for bricks to impart a gray color. It is compressed in cylinders as the negative element of the Leclanché cell. It is the usual source of other Mn compounds, and unites with stronger bases to form manganates.

Iron.—Ferric oxid, Fe_2O_3, is obtained as a residue in distilling fuming sulphuric acid from green vitriol. It is a dark-red powder used in paints, and as a polishing agent under the names jewelers' rouge, colcothar, and caput mortuum. Ferroso-ferric oxid, Fe_3O_4, is the natural black magnetite or lodestone, and is the chief constituent of "blacksmiths' scales." Barff's process for preventing rusting of iron consists in coating the article with a film of Fe_3O_4 (prevents further oxidation), produced by a current of steam passed for a few minutes over the iron raised to a red heat.

Gold.—Au_2O, aurous oxid, is a dark-violet powder; Au_2O_3, auric oxid, a dark-brown powder. Au_2O_3 and PtO_2 lose their O at low red heat. The purple of Cassius, a compound of Au, Sn and O (or a suspension of fine red gold in $Sn[OH]_4$), is used for the gum color of porcelain teeth and to impart a red color to glass and porcelain.

Silver.—Argentous oxid, Ag_4O, is a black lustrous mass obtained by heating $Ag_3C_6H_5O_7$ to 100° and at same time subjecting to H. Argentic oxid, Ag_2O, is produced by reaction of hydroxids on $AgNO_3$. It is a heavy, blackish, amorphous, slightly soluble, oxidizing powder. Highly explosive crystals of Berthollet's fulminating silver are produced by dissolving Ag_2O in strong NH_4HO and diluting with H_2O. The peroxid, Ag_2O_2, is even stronger as an oxidizer than Ag_2O.

Miscellaneous.—CoO and NiO are both green powders. OsO_4 ("osmic acid") is a delicate histologic stain (1 per cent.) for fat (stains black by reduction to lower oxid). Oxids of Th, Ce and Zr are used for the mantles of incandescent gas-lights. ThO_2 is the white powder left as a coherent mantle on firing the cotton netting of a Welsbach mantle saturated with nitrate.

NON-METALLIC OXIDS.

These are gases, liquids, or solids composed of O united to some electronegative element. Many of them are termed anhydrids, since they join with water to form acids. Some of them, as As_2O_3, are improperly termed acids.

Halogens.—Three oxids of Cl are known: namely, monoxid, Cl_2O; trioxid, Cl_2O_3; and tetroxid, or peroxid, Cl_2O_4. They are all heavy, greenish-yellow gases, with strong, irritating odors, and easily condensed to reddish liquids. In combination with H_2O the first and second form, respectively, hypochlorous and chlorous acids. On account of the slight affinity of O for Cl, they are very unstable, and ignite or explode easily.

Experiment. To Illustrate One Form of Spontaneous Combustion.—To a little $KClO_3$ in a beaker add a few drops of H_2SO_4. When the beaker is about filled with the greenish gas, drop into it a small piece of tissue-paper saturated with turpentine.

No oxids of Br or F are known. The only oxid of I is the pentoxid, I_2O_5. This is a white, crystalline powder, very soluble in water, with which it forms iodic acid, HIO_3.

Sulphur.—Four oxids are known; sesquioxid, S_2O_3; dioxid, SO_2; trioxid, SO_3; and heptoxid, S_2O_7. The first and last are of no practical interest. SO_2 is formed whenever S is burned in air. One kgm. of S produces 100 liters of SO_2. It may be made pure by heating together S and H_2SO_4.

$$S + 2H_2SO_4 = 3SO_2 + 2H_2O$$

Another laboratory method is to heat H_2SO_4 with C or Cu. A convenient method of generating SO_2 is by treating $CaSO_3$ cubes with HCl.

SO_2 forms a large percentage of volcanic vapors, and is abundant in the air of large cities from combustion of coal in stoves and furnaces. It is a colorless gas with a suffocating sulphurous odor, and is very hygroscopic, 43½ volumes dissolving in 1 part of H_2O at 20°. It is neither combustible nor a supporter of combustion, but reduces O compounds actively. It removes fruit stains. It bleaches straw, wool, and silk in the presence of water, by combining with the O of H_2O, leaving H free to unite with the O of the organic coloring matter; the color may be restored by neutralizing with an alkali. Large quantities of SO_2 are evolved in bakers' ovens and in the refining of petroleum.

Experiment.—Place some fresh flowers on a tripod, and ignite a little S beneath, covering the whole with a bell jar. The flowers are bleached, but may have their color restored by washing with a dilute alkali (removes SO_2) or with very dilute HNO_3 (restores O removed by SO_2).

As an anhydrid SO_2 decomposes NH_3, ptomains, sulphids, and H_2S, and kills bacteria. It is extensively used for fumigation of sickrooms and in preserving meats. Aside from its odor, SO_2 is detected with paper saturated in solution of KIO_3 and starch, which turns blue, but is bleached by excess of gas.

$$2KIO_3 + 5SO_2 + 4H_2O = 2KHSO_4 + I_2 + 3H_2SO_4$$

SO_3 is prepared most readily from fuming Nordhausen acid by application of heat, as follows:—

$$H_2S_2O_7 = H_2SO_4 + SO_3$$

SO_3 appears in long, silky, transparent prisms, and is used in the manufacture of alizarin and for dissolving indigo. With H_2O it combines energetically to form H_2SO_4. The haze over large cities is partly due to decomposition by sunlight of SO_2 (from combustion) into SO_3 and free S.

Nitrogen.—There are 5 oxids of N: namely, N_2O, N_2O_2 (NO), N_2O_3, N_2O_4 (NO_2), and N_2O_5. All are unstable and easily dissociated by heat. They are formed in Nature by the passage of electricity through the atmosphere.

N_2O (nitrous oxid, or laughing-gas) was discovered by Priestley in 1772. It is prepared by cautiously heating (between 210° and 250°) NH_4NO_3, which breaks up as follows:—

$$NH_4NO_3 = N_2O + 2H_2O$$

For anesthetic use N_2O should be purified of the higher oxids by passing the gas through two wash-bottles, one containing NaHO, the other $FeSO_4$. N_2O is a colorless, odorless gas of sweet taste, soluble in about 1 volume of H_2O. It is a decided disinfectant and a supporter of combustion, parting readily with its O. It has received the name laughing-gas because of the exhilarating effects it first evokes when inhaled. N_2O is much used by dentists as a pleasant and safe anesthetic for short operations. It is kept for convenience in the liquid state (30 atmospheres at 0°) in wrought-iron cylinders, vaporizing as soon as the pressure is removed. It must be used with access of air or O (20 per cent.). Blood-pressure is much augmented under N_2O. Alarming symptoms are best treated with fresh air or O and stimulants. Liquid laughing-gas is a useful refrigerant agent.

Experiment.—Make N_2O and note properties.

Nitric oxid, N_2O_2, is prepared by the reduction of HNO_3 with metals:—

Experiment.—Pour HNO_3 on Cu, forming N_2O_2, a colorless gas, which in contact with the O of air becomes N_2O_4: an oxidizing agent characterized by red fumes. This is also a test for HNO_3.

$$3Cu + 8HNO_3 = 3Cu(NO_3)_2 + N_2O_2 + 4H_2O$$

N_2O_3 is a dark-blue liquid, made by warming HNO_3 with starch. It combines directly with H_2O to form HNO_2. N_2O_5 is a white, crystalline solid, obtained by treating dry $AgNO_3$ with Cl. It has a strong affinity for H_2O, with which it forms HNO_3.

Phosphorus.—The oxids of P, P_2O_3, and P_2O_5, respectively, are formed by the slow oxidation and by the rapid combustion of P. The former, a white amorphous powder with garlicky odor, unites with H_2O to form phosphorous acid, H_2PHO_3, the salts of which, termed phosphites, are of no medical interest. The white fumes of P_2O_5 have an eager affinity for H_2O, forming with it metaphosphoric, pyrophosphoric, or orthophosphoric acid, according as 1 molecule of the gas unites with 1, 2, or 3 molecules of H_2O.

Boron.—B_2O_3 is generally prepared by heating boric acid to redness:—

$$2H_3BO_3 = B_2O_3 + 3H_2O$$

It is a colorless, vitreous solid, and is used in blowpipe work to convert nitrates, carbonates, and other salts into borates.

Silicon.—A grain of sand is, chemically speaking, silica, silex, or oxid of silicon, SiO_2, of which there are three varieties (two crystalline, one amorphous) mentioned under ores. It is very abundant in rocks and soils, and is found in traces in all natural waters. Silica gives stiffness to stalks of grain and grass, and is present in the blood, hair, and bones of mammals. In the "petrified wood" found in Colorado and Arizona the C of former submerged forest-trees has been replaced by SiO_2 (sometimes lime salts). Quartz is soluble only in HF. The other varieties of SiO_2 are also soluble in boiling solutions of alkaline hydroxids or carbonates.

All forms of silica find extensive industrial uses, particularly in the manufacture of glass, pottery, and artificial teeth. Agate is used for the hardest mortars. Kieselguhr, or diatomaceous earth, is an amorphous form of SiO_2 used as an absorbent for nitroglycerin in the production of dynamite. A little sand sprinkled on the hot iron aids the process of welding by forming with the surface oxid a fusible slag.

Experiment.—Heat before blowpipe a bead of microcosmic salt touched with a minute grain of sand, and note "silica skeleton" formed in bead.

Carbon.—Carbon monoxid, CO, is a colorless, almost odorless, gaseous, unsaturated compound produced by incomplete combustion of C or carbonaceous substances in a deficient supply of O. It is formed in base-burner stoves at night, when but little air is allowed to enter the stove; also when there is a defective draught. The gas burns with a bluish flame, forming CO_2. It is an active reducing agent. C burns directly to CO at 1000°; hence the latter is produced in blast and electric furnaces (gassing); also from blasting in mines, lamps turned low, imperfect dampers, open stove-lids and grate fires.

Experiment.—Make CO by warming 1 part $K_4Fe(CN)_6$ with 9 parts of H_2SO_4.

$$K_4Fe(CN)_6 + 6H_2SO_4 + 6H_2O = 2K_2SO_4 + 3(NH_4)_2SO_4 + FeSO_4 + 6CO$$

CO_2 was the first gas to be separated from air, this event taking place in the seventeenth century. Pure country air contains 4 parts of CO_2, by volume, in 10,000. The amount in the atmosphere is greatest at night. More than 7 parts in 10,000 are oppressive and injurious. This gas is also present in all natural waters, being most abundant in certain mineral springs; also in beer- and wine-vats; and is the "choke-damp," or "after-damp," of wells and mines. It is produced by burning C with a free supply of air; also by respiration (expired air contains 4 to 5 per cent.), ordinary fermentation, and the oxidation and decay of organic matter. One acre of good garden land in the course of a summer evolves more than 16 tons of CO_2. An ordinary lamp sets free in burning as much CO_2 as an adult person; a gas-jet two to four times as much. Artificially CO_2 is prepared by action of any common acid (mineral ones usually employed) on a carbonate.

Experiment.—Make CO_2 by treating Na_2CO_3 with HCl, and test gas by passing into lime water. Notice that the lime water becomes at first cloudy, and then again when surcharged clear, owing to the formation of the more soluble acid carbonate of Ca.

CO_2 is a colorless gas with a sharp taste and acid smell. It turns blue litmus purple or wine-red, the blue color being restored by heat. Although it is half again as heavy as air at the same temperature, the foulest air in a living-room is next the ceiling, because of the warming by the blood of the exhaled gas, and also since ventilation is usually less perfect at the top of the room. In wells and mines the gas is most abundant at and near the bottom. The CO_2 liberated from the rootlets of plants etches limestone and sandstone but not aluminum phosphate.

CO_2 is soluble in 1 volume H_2O with chemic union, forming H_2CO_3. The popular beverage known as soda-water contains 5 volumes of this gas to 1 of water. The gas is forced in under pressure, which is relieved for each glass of the liquid drawn, with consequent effervescence. CO_2 for soda-water is now sold liquefied by a pressure of 40 atmospheres in steel cylinders. On evaporation this liquid produces intense cold (— 110°). When the iron container of liquid CO_2 is inverted and the content is allowed to escape into a bag of chamois (several thicknesses), bound to the outlet, a snow-white solid is formed which is used for treating by congelation warts, calluses, senile keratoses, nevi, lupus erythematosus and small superficial epithelioma. Many mineral waters are artificially carbonated. This CO_2 is a stimulant to gastric secretion and movements but may depress appetite.

CO_2, being an acid gas, has marked affinity for alkaline solutions.

Experiment.—Show absorption of CO_2 by alkaline hydroxids by adding to test-tube or jar of gas a solution of KHO and shaking well, then remove stopper under water, and the latter rushes in to take the place of absorbed gas.

CO_2 is neither combustible nor a supporter of combustion, and is used to some extent as the "chemic fire-extinguisher."

Experiment.—Invert candle into jar of CO_2. Burn a strip of Mg in the same jar and note brilliancy of flame (incandescent MgO) and black particles of C formed.

Experiment.—Light candle again and place under bell jar filled with air. When CO_2 amounts to 12 per cent. the light goes out.

Hydrogen.—Hydrogen peroxid, H_2O_2, is a colorless, syrupy liquid (sp. gr., 1.45), with a sharp odor and tingling, metallic taste (due to a trace of H_3PO_4). It is very soluble in ether and water. It is usually prepared as per the following equation:—

$$3BaO_2 + 2H_3PO_4 = Ba_3(PO_4)_2 + 3H_2O_2$$

or more easily by passing CO_2 into aqueous suspension of BaO_2. Other acids may be used. It is concentrated by evaporating at not above 60°. In concentrated form for use as a bleaching agent, it is prepared by the action of dilute acids on Na_2O_2.

It corrodes metals and decomposes readily into H_2O and nascent or atomic O, on exposure to air and sunlight, and especially when heated; hence it is a strong oxidizer, and should be kept in a cool place well stoppered.

Experiment.—Prove oxidizing action of H_2O_2: To a little H_2O_2 solution add a drop each of K_2CrO_4 and H_2SO_4 and a little ether, and shake. A blue color, due to perchromic acid, results.

On account of its unstable character, H_2O_2 should not be prescribed with any other substance than H_2O. The ordinary solutions of this compound vary in strength from 1 to 10 volumes of available O or up to 3 per cent. by weight of pure dioxid. Boric acid, acetanilid, and glycerin are of value as preservatives for these preparations. The peroxid is much employed for bleaching wool, teeth, and hair (combined with weak alkalies) and for cleansing (brightens old books and pictures) and antiseptic purposes. It is particularly useful in treating abscess cavities; the chemic action that ensues drives out the pus with effervescence. It also effervesces with blood, saliva, and other organic substances.

A solution in ether is called ozonic ether. Some H_2O_2 is formed in growing plants, but quickly decomposes into H_2O and O.

Special Test.—H_2O_2 gives a blue color with a solution containing starch, KI, and $FeSO_4$.

$$2KI + H_2O_2 = 2KHO + I_2$$

Arsenic.—As_2O_3 (arsenous oxid, white arsenic) was known as early as the eighth century. It is the "arsenic bloom" of miners, and is obtained as a side-product in roasting ores containing As. The powder has a sweetish, disagreeable, metallic taste. It volatilizes at 218°. It is usually a mixture of vitreous and crystalline (porcelain like) varieties; the vitreous becomes crystalline by absorption of H_2O. Its solubility varies with the physic condition, the amorphous, glassy variety requiring but 30 parts of cold water, whereas the opaque, crystalline form is dissolved by not less than 80 parts. Without boiling, a fluidounce of cold water will dissolve only ½ to ¾ grain As_2O_3. The solubility of either variety is greatly increased by the addition of a little HCl or alkali. It is also soluble in 5 parts of glycerin. It is much used in medicine and dentistry; in embalming, taxidermy, manufacture of green colors and opaque white glass; as a preservative against worms in ship-building, and as an insecticide spray for trees and shrubs; in calico-printing, and as the source of all As compounds. As_2O_3 is used largely in dentistry as a devitalizing agent, usually mixed with morphin or cocain and creosote, oil of cloves or phenol, sealed in with gutta-percha or other protective. It "kills the nerve" by causing such an irritant congestion of the pulp as to lead to strangulation of the vessels at the apex of the tooth. It is used by "cancer specialists" as an escharotic to "eat out" these tumors. Liquor acidi arsenosi is a 1-per-cent. solution of As_2O_3 in water containing 5 per cent. of dilute HCl.

As_2O_5 (arsenic oxid) is of little medical interest; it is usually prepared by warming As_2O_3 with HNO_3. Both this oxid and arsenic acid are used as oxidizing agents in the preparation of anilin colors.

Antimony.—The trioxid is a heavy, light-gray powder, insoluble in HNO_3, but readily dissolved by HCl, warm $H_2C_4H_4O_6$, or $KHC_4H_4O_6$. It is used in preparing tartar emetic and as a substitute for white lead.

INORGANIC ACIDS.

These are strongly acid, as a rule, and attack most metals, forming salts, with evolution of H. Fuming acids (HNO_3, HCl, HI) give off an acid gas, which combines with atmospheric moisture and forms a visible vapor. Mineral acids owe their physiologic action almost entirely to the H (stronger than K) ion. These acids abstract water (astringent) and coagulate the superficial layer of proteids in the skin, giving rise to stiffness and numbness or a puckery feeling. They diminish febrile thirst (refrigerant action) by stimulating the flow of saliva and other alkaline fluids. Mineral acids are excreted chiefly as NH_4 salts, ammonia being liberated by the tissues for self-protection and to save the fixed alkalies from combining with the acids. Acids are protoplasm poisons, and when administered in large doses animals die before their blood becomes even neutral.

HYDRO-ACIDS.

These are solutions of colorless, acid gases in H_2O. They have a sharp, irritating odor. Their vapors redden moistened blue litmus-paper. They are generally prepared by treating the appropriate salt with H_2SO_4 or H_3PO_4. They should leave no residue on evaporating to dryness. Their tests are, in general, the same as for their salts, but a few special ones are given below.

HCl is the most important of the hydro-acids. In the pure state it is a non-combustible gas one-fourth heavier than air. It is found naturally in the atmosphere, especially near volcanoes and chemic works, and also in the human gastric juice (0.1 or 0.2 per cent.). HCl is usually manufactured from common salt by the chemic action thereon of H_2SO_4, with the aid of heat.

$$2NaCl + H_2SO_4 = Na_2SO_4 + 2HCl$$

Experiment.—In a suitable flask place ½ inch dry NaCl, fill flask ⅓ full with dilute H_2SO_4, heat till boiling hard, then pass gas into H_2O in beaker. It may be purified by redistillation.

On a large scale HCl is a leading by-product in the manufacture of soda and it is freely generated in potteries. HCl causes a red stain on dark cloths, readily removed by NH_4HO.

HCl gas is extremely soluble in H_2O, 1 volume of the latter at 0° dissolving 503 volumes, or 82 per cent., by weight, of the former. This is not a simple solution, since heat is produced and the b.p. of the water is increased. The water increases more than one-third in bulk. This solution has bleaching and antiseptic properties and is much used as a reagent. The commercial acid (yellow from iron) is employed for renovating brick fronts. It contains on the average 0.25 per cent. of As_2O_3.

Experiment.—Show intense avidity of HCl gas for H_2O by opening a test-tube of the gas under water, tinged with blue litmus. Explain color change and why the water rises in the tube.

The official HCl contains 32 per cent., by weight, of the gas, and has a sp. gr. of 1.16. The dilute acid is of 10-per-cent. strength; sp. gr., 1.05. The yellow color of common HCl is due chiefly to Fe compounds. HCl is used extensively in medicine, particularly when there is a deficiency of the acid in the gastric juice. In manufacturing chemistry it is employed in the preparation of chlorates, chloroform, and bleaching powder.

Nitrohydrochloric acid (aqua regia) is made by mixing 180 c.c. HNO_3 with 820 c.c. HCl, letting them stand for a week or two. The reactions between the two acids are as follows:—

$$HNO_3 + 3HCl = NOCl + 2H_2O + 2Cl$$
$$HNO_3 + 3HCl = NOCl_2 + 2H_2O + Cl$$

It will be seen that HNO_3 oxidizes the H of both acids. The solvent power of aqua regia on Au and Pt depends on its free Cl and the chloronitrous and chloronitric gases, which give up their Cl very easily. Nitromuriatic acid dissolves any organic matter, with evolution of ruddy fumes.

Special Test for HCl.—Dense, white fumes (NH_4Cl) appear when a glass rod dipped in NH_4HO is held over mouth of container.

HBr can be prepared from any bromid (usually KBr) by treating it with concentrated H_2SO_4. The dilute HBr of the United States Pharmacopeia contains 10 per cent., by weight, of the absolute acid gas dissolved in distilled H_2O, and has a sp. gr. of 1.077. Quinin is sometimes administered in dilute HBr, the Br of the acid neutralizing the hyperemic effect of the alkaloid on the inner-ear.

Special Test for HBr.—Reddish fumes when heated with strong H_2SO_4.

The official syrup of HI is of a 1-per-cent. strength; the sugar serves to prevent actinic decomposition. HI readily parts with its H and is therefore an active reducing agent, being used in photography.

Special Test for HI.—Gas gives brown color to paper moistened with Cl water.

The only important artificial compound of F is HF, prepared by gently heating in a leaden dish CaF_2, treated with an excess of H_2SO_4. The HF gas thus formed combines with the silica of the glass, owing to which fact it has been used more than two hundred years for etching glass.

Experiment.—Show action of fresh HF on glass covered with a paraffin coating in which a design has been traced down to the glass.

$$SiO_2 + 4HF = 2H_2O + SiF_4 \text{ (a gas).}$$

An aqueous solution of HF is used for marking thermometers and glass measures. It is very volatile and caustic, producing painful and slow-healing ulcers if allowed to come in contact with the skin. The local effect of the acid can be neutralized to some extent by applying NH_4HO or some other weak base. The dilute acid is stored in gutta-percha bottles.

H_2S (sulphydric acid) is a sweet-tasting, foul-smelling (1 part in 10,000 recognized by odor) gas derived from the putrefaction of organic bodies containing S (eggs, for instance), and also present in many mineral waters. It is the chief constituent of sewer-gas, and burns in air with a blue flame. H_2S is prepared for laboratory use by treating FeS with H_2SO_4 (1 to 6). A c.p. grade is also prepared by treating a concentrated solution of $Ca(SH)_2$ with HCl.

At mean temperature water dissolves 3½ times its volume of H_2S. H_2S in solution is a strong reducing agent, taking O from the air, forming H_2O with deposit of S. The water should first be boiled and the solution kept in a well-filled, well-stoppered bottle. The addition of a little glycerin also aids in preserving the strength of the solution.

This gas tarnishes silverware, and also combines with many other metals, giving precipitates with characteristic colors.

Experiment.—Show reaction of H_2S on solutions of Pb, Sb, As, Sn, and Zn salts. $Pb(C_2H_3O_2)_2$ reacts to one part of H_2S in a solution of 250,000 parts of water. H_2S with ferrous salts gives no ppt.; with ferric salts, a white ppt. of S and reduction to the ferrous state.

Aside from the odor, we may detect very small quantities of the gas by saturating a piece of white filter-paper with lead acetate solution, and exposing it for some hours where we have reason to suspect the gas is escaping. The sulphids, or salts of H_2S, constitute the most common ores of the more common metals. The black stools often noticed after taking Fe, Bi, or Pb salts are due simply to the union of the medicine with the H_2S formed by putrefaction in the alimentary tract. Pathologically H_2S is present in fetid abscesses, and the odor of the gas in the urine in some cases aids to determine the rupture of an internal abscess into the urinary tract or a fistulous communication between the bladder and the rectum.

Iodic acid is used as a test for morphin. It yields O readily and is reduced to brown I. Hydrochlorauric acid, $HAuCl_4$, is obtained in yellow crystals by careful evaporation of aqua regia solution; stronger heat drives off HCl and leaves brown $AuCl_3$. This acid forms a large series of double salts, such as chloraurate of Na, $NaAuCl_4.H_2O$, used in photography as a wash to give a brown-violet tone of reduced gold.

Chloric, perchloric, hypochlorous, hypobromous, bromic, periodic, cyanic, thiocyanic, ferrocyanic, ferricyanic, manganic, permanganic, chromic, stannic, and antimonic acids have no practical interest.

THIO-ACIDS.

The most important and most powerful of the mineral acids is H_2SO_4, or sulphuric acid. It occurs free in the atmosphere near chemic works and in volcanic springs and rivers (Andes). The principal sources of this acid are S and FeS_2. The process of manufacture of H_2SO_4 commonly depends on the oxidation of SO_2 into SO_3 in the presence of H_2O as steam. The intermediate agent in oxidation is N_2O_4, formed by treating $NaNo_3$ with H_2SO_4. This gas, N_2O_4, gives up two atoms of O to SO_2, and is reduced to N_2O_2, which again takes up the O from the air at hand, and so the reaction goes on indefinitely as long as the fumes of burning S or FeS_2 are passed into the chamber along with steam and air.

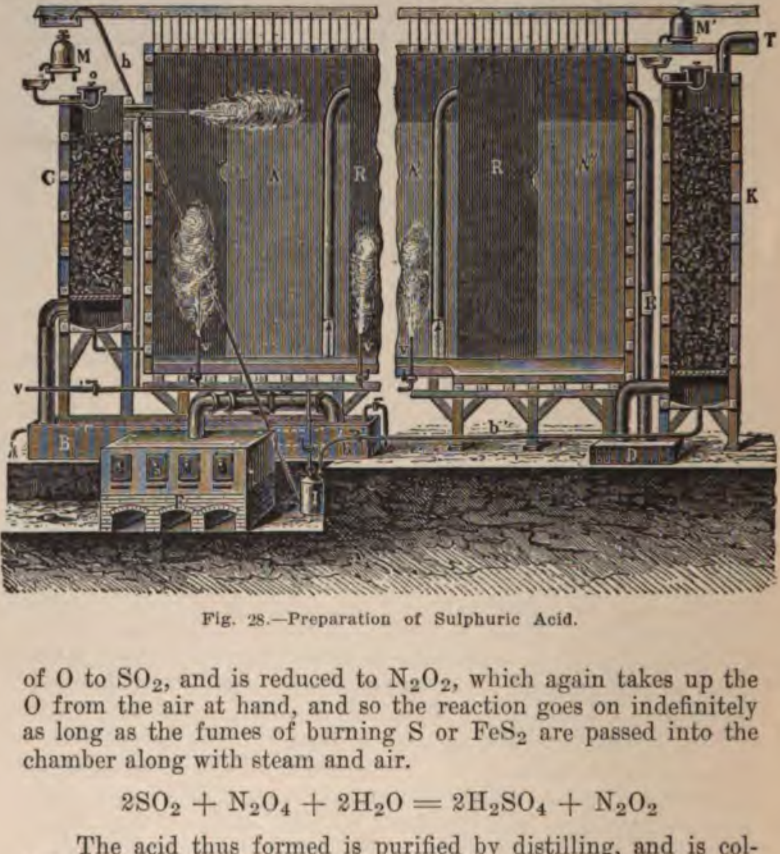


Fig. 28.—Preparation of Sulphuric Acid.

$$2SO_2 + N_2O_4 + 2H_2O = 2H_2SO_4 + N_2O_2$$

The acid thus formed is purified by distilling, and is collected in leaden pans, concentration being completed in glass or Pt vessels. In the new method of making H_2SO_4, Pt is employed as a catalyzing agent, air and SO_2 (from iron pyrites free from As) being passed over finely divided Pt at a definite temperature, forming SO_3. The acid is purified by distilling with asbestos.

Experiment.—Make H_2SO_4 by carefully heating a little S and $KClO_3$ in a test-tube till they ignite. Add H_2O and test for acid as under "Sulphates."

H_2SO_4 is a colorless, odorless, oily, corrosive liquid of 96-per-cent. strength; sp. gr., 1.84. The official acid is 92½ per cent.; sp. gr., 1.826. The aromatic sulphuric acid contains also alcohol and aromatics, and is of 20-per-cent. strength.

H_2SO_4 is intensely avid of H_2O, and to this is due, in part the characteristic effects of the acid on organic substances.

Experiment.—Show charring action of strong H_2SO_4 on white sugar. On account of its hygroscopic properties, H_2SO_4 is much employed in desiccators. It combines with $2H_2O$ to form H_6SO_6 (orthosulphuric acid), the reaction being attended by considerable heat and by 8-per-cent. reduction in volume. When mixed with H_2O the acid should be added gradually to the water, and not the water to the acid, as in the latter event the acid steam that is thrown off may scald a person. Dilute H_2SO_4 attacks metals more rapidly than the strong acid, since in the latter case the chemic action is soon hindered by the coating of sulphate that forms on the metal. Strong H_2SO_4 on black cloth leaves a damp spot which is at first red (no change if indigo-blue; yellow with logwood and madder; white linen or cotton blackened and eroded), later dirty brown and rotten. Conc. H_2SO_4 heated with metals evolves SO_2, not H.

H_2SO_4 is more extensively employed industrially than any other chemic compound. A million tons of the acid are consumed annually in England in the Leblanc soda-process. Other uses of this acid are in the manufacture of HNO_3, of ether, nitroglycerin, guncotton, parchment-paper, and fertilizers, the production of CO_2 from marble-dust, the conversion of starch into glucose, the refining of petroleum, the separation of Ag and Au, drying of gases and precipitates, and in the dental laboratory the dilute acid is employed as a "pickle" for cleaning metallic plates before and after soldering.

Sulphurous acid, H_2SO_3, is formed by passing SO_2 into H_2O, or by the reducing action of S or charcoal on H_2SO_4.

Experiment.—Make H_2SO_3 by placing 10 or 20 gm. charcoal in a flask, covering with H_2SO_4 and applying heat, passing gas through wash-bottle and collecting in water. Identify by blue color produced with starch and iodic acid—sensitive 1:3000.

Sulphurous acid is a colorless liquid; sp. gr., 1.028; of not less than 6.4-per-cent. strength, by weight, with an acid, sulphurous taste and smell. It first reddens, then decolorizes, litmus; and is used to some extent as a bleaching and disinfecting agent. Decolorization of an I solution with this acid depends on the conversion of I into HI as follows:—

$$H_2SO_3 + I_2 + H_2O = H_2SO_4 + 2HI$$

Experiment.—Show bleaching effect of H_2SO_3 on permanganate solution.

Both the acid and its salts are detected by giving a light-colored ppt. with Ag, Pb, or Hg, which blackens on heating, owing to the change of sulphite into sulphid.

The fuming Nordhausen acid, $H_2S_2O_7$, is a thick, oily liquid obtained by roasting basic pyrites ($Fe_2S_2O_9$) or by passing SO_3 (from heated $FeSO_4$) into H_2SO_4. This acid is a solvent for indigo.

Hyposulphurous acid, H_2SO_2, is prepared by the reducing action of Zn on H_2SO_3. It is a yellow, unstable liquid; a powerful bleaching agent; and it ppts. the metals from solutions of their salts, as in the following reaction:—

$$HgCl_2 + H_2SO_2 + H_2O = Hg + 2HCl + H_2SO_3$$

Experiment.—Show reaction represented by above equation.

Among other sulphur acids of little importance may be mentioned $H_2S_2O_3$ (thiosulphuric), $H_2S_2O_6$ (dithionic), $H_2S_3O_6$ (trithionic), $H_2S_4O_6$ (tetrathionic), $H_2S_5O_6$ (pentathionic), and $H_2S_2O_8$ (persulphuric). H_2S (hydrosulphuric acid) has been discussed already under "Hydro-acids."

CARBONIC ACID.

H_2CO_3 is not known in a free state, since it splits up into CO_2 and H_2O as soon as formed.

SILICON ACIDS.

Metasilicic acid, H_2SiO_3, is a clear, limpid fluid in colloidal solution, tending to become gelatinous. Most silicates in nature are derived from this acid.

Hydrofluosilicic acid, H_2SiF_6, is known only in solution. It dissolves metals, forming silicofluorids, which are pptd. by K salts as gelatinous K_2SiF_6.

BORIC OR BORACIC ACID.

H_3BO_3 is obtained by evaporation from the steam-jets or fumeroles in the volcanic regions of Tuscany. In the United States it is also prepared by treating borax with HCl. Another source is the calcium borate obtained from Death Valley and the Mojave Desert. The pure acid is a white powder, unctuous, odorless, and nearly tasteless. It is soluble in 26 water, 15 alcohol, and 10 glycerin.

Special Tests.—The solution in alcohol burns with a green-tinged flame. Dissolve in hot water and dip turmeric paper in solution. Color of paper unchanged, but on drying becomes brown-red, turning green on moistening with KHO.

Boric acid is a valuable non-toxic and non-irritating antiseptic, which can be used with safety in any part of the body.

It is often added to alkaloidal substances—*e.g.*, cocain—to prevent decomposition.

Boroglycerid is a thick, syrupy liquid, made by heating together 1 part of the acid with 1½ parts of glycerin. It is an antiseptic depletant. H_3BO_3 and boroglycerid are each used in combination with Na_2SO_3 for bleaching discolored teeth.

When heated to 100°, H_3BO_3 loses H_2O and becomes metaboric acid, HBO_2, which on further heating (140°) is converted into tetraboric acid, $H_2B_4O_7$, of which borax is the principal salt.

Experiment. Incombustible Fabrics.—Dissolve 20 gm. borax and 25 gm. $ZnSO_4$, each in 150 c.c. H_2O, and mix solutions. Then add a like amount each of NH_4HO and H_3PO_4. Dip a paper in the mixture, let dry, and test with a lighted match.

NITRO-ACIDS.

True nitrous acid, HNO_2, is a very unstable blue liquid, made by passing N_2O_3 into ice-water, or by warming HNO_3 with starch-water.

Nitric acid, HNO_3, is generally prepared commercially by the action of H_2SO_4 on KNO_3. The pure acid is a colorless, fuming, suffocative, and very corrosive liquid; sp. gr., U. S. P., 1.403; of 68-per-cent. strength. The dilute acid is of 10-per-cent. strength; sp. gr., 1.054. Single aqua fortis (commercial; sp. gr., 1.25) contains 39 per cent. of HNO_3; the double contains 64 per cent.

Experiment.—Show corrosive action and yellow color (xanthoproteic test) of HNO_3 on black, woolen cloth. The same color is noticed on the nails, skin, or any nitrogenous substance.

It parts easily with some of its O, and is, hence, a strong oxidizing agent, for which reason it should never be prescribed with sugar, alcohol, glycerin, oils, or other combustible substances.

The fuming acid is brownish red on account of containing NO_2 in solution. HNO_3 on exposure to light and air decomposes into a yellowish liquid, nitroso-nitric acid, which contains NO and is commercially known as nitrous acid.

HNO_3 is used internally (diluted) and as a caustic; also in refining metals and engraving Cu plates, and in the manufacture of guncotton, nitroglycerin, and anilin dyes. It is used by metal workers for cleansing before gilding and lacquering.

Test for Strong Acid.—Red fumes of N_2O_4 evolved on heating with Cu foil or filings. Green cupric nitrate is formed, H is evolved, and partly deoxidizes some HNO_3 ($HNO_3 + 3H = 2H_2O + NO$), forming NO (N_2O_2), which takes up O_2 from air and becomes colored.

Test for Dilute Acid.—Add some $FeSO_4$ to suspected liquid, and slide under mixture strong H_2SO_4. A brownish or black ring at point of contact proves presence of HNO_3.

Triazoic or hydrazoic acid, N_3H, is a colorless gas with a disagreeable odor, made by treating Na with NH_3; the NH_2Na

thus formed, with N_2O; and the resulting N_3Na, with an acid. It is both explosive and poisonous.

PHOSPHORUS ACIDS.

Orthophosphoric acid, H_3PO_4, is prepared by boiling P with dilute HNO_3 or by treating any phosphate with H_2SO_4. That used in dental cements is prepared by dissolving HPO_3 in warm water and evaporating to a syrupy consistence. The United States Pharmacopeia preparation is a colorless, odorless, syrupy liquid containing at least 85 per cent. of absolute acid; sp. gr., 1.7. The dilute formula contains 10 per cent. of absolute acid. H_3PO_4 is a tribasic acid, forming normal, acid, and double salts. It is not volatilized by red heat. Evaporating spontaneously, it yields prismatic crystals.

When H_3PO_4 is heated to about 200° it loses water and is converted into pyrophosphoric acid, $H_4P_2O_7$.

$$2H_3PO_4 - H_2O = H_4P_2O_7$$

When $H_4P_2O_7$ is heated nearly to redness, it is also dehydrated into glacial phosphoric or metaphosphoric acid, HPO_3: a colorless, glassy solid. Both this acid and $H_4P_2O_7$ are corrosive and paralyzant poisons, acting especially on the innervation of the heart.

Hypophosphorous acid, HPH_2O_2, is a white, crystalline substance, obtained by decomposing $Ca(PH_2O_2)_2$ with oxalic acid. It is a strong deoxidizer. The dilute acid is of 10-per-cent. strength. On exposure to air it takes up O and becomes the colorless liquid phosphorous acid, H_3PO_3. This, in turn, is oxidized into H_3PO_4.

Differential Tests.—H_3PO_4 gives a yellow ppt. of Ag_3PO_4 with argent-ammonium hydrate: soluble both in HNO_3 and NH_4HO. Orthophosphoric acid gives a yellow ppt. with $AgNO_3$; meta- and pyro- white. Pyrophosphoric acid gives white ppt. with $MgSO_4$; metaphosphoric acid none at all.

ARSENOUS AND ARSENIC ACIDS.

H_3AsO_3 is not known in the free state, but exists in solutions of As_2O_3. H_3AsO_4 appears in white, deliquescent crystals, which are strongly corrosive and blister the skin. Its solutions give a brick-red ppt. of Ag_3AsO_4 on adding argent-ammonium hydrate.

HYDROXIDS.

These may be regarded as H_2O in which one-half of its H is replaced by a metal. They are chiefly white, crystalline, deliquescent solids (except NH_4HO) with strongly alkaline reaction and caustic, alkaline taste. They are commonly purified by dissolving in alcohol and decanting. Commercial preparations contain from 10 to 25 per cent. H_2O and nearly always a little As. Hydroxids of the alkaline metals and alkaline earths are more or less soluble in H_2O; all others insoluble. Solution produces considerable heat on account of taking up water of crystallization. The soluble hydroxids are recognized by melting and volatilizing unchanged, by dissolving in HCl without odor or effervescence, and by giving a dark-brown ppt. of Ag_2O with $AgNO_3$, soluble in excess—deposits fulminating silver on free exposure to air. The insoluble ones give off steam when heated in a nearly horizontal, dry test-tube, leaving a residue of oxid. Alkalies give a white ppt., turning blue, with ferrous salts; red-brown, with ferric salts. PCl_5 is a test for OH in any compound, yielding HCl and H_3PO_4.

Hydrates of the alkaline metals owe nearly all their action to the relatively powerful anion hydroxyl. Carbonates and bicarbonates of these metals, by dissociation and combination with water (liberating HO) have properties similar to hydroxids, though weaker. All these alkalies dissolve proteins (including mucus), saponify fat, soften the skin and remove horny layers of epithelium. Alkaline hydrates and carbonates render the blood and tissues more alkaline, aiding oxidation. Owing to its volatility, ammonia is more penetrating than the fixed alkalies, but is less caustic.

KHO is now prepared commercially by electrolyzing KCl, using a cathode of Hg, the amalgam in contact with water forming the hydroxid. KHO is soluble in 0.5 H_2O or 2 alcohol; the alcoholic solution soon turns dark yellow to brown, forming, in presence of air, aldehyd and acetic acid. Potassa fusa is KHO heated and run into cylindric molds. Official liquor potassæ is 5 per cent. in strength, with sp. gr. of 1.046. Potassa cum calce is a caustic paste composed of equal parts of KHO and CaO. Robinson's remedy contains equal parts of KHO and carbolic acid. NaHO is soluble in 1.7 H_2O and is very soluble in alcohol. Liquor sodæ contains about 5 per cent. NaHO, and has a sp. gr. of 1.056. Crude NaHO has extensive use in soap-making.

Ammonia, NH_3, is a gaseous compound present in the atmosphere in minute amounts in combination with nitrous, nitric, and carbonic acids. It is a product of organic decomposition and dry distillation; soft coal yields about 2 per cent. Its chief source at present is the ammoniacal liquors formed during the manufacture of illuminating gas. The gas is freed from its compounds in this liquid by distilling with lime and collecting in water. NH_3 is colorless, and has a sharp, suffocating smell. When mixed with O it ignites, forming N, H_2O, and HNO_3. It is liquefied by freezing mixtures at — 40° or by a pressure of 6 or 7 atmospheres. The liquid boils at — 38.5°, absorbing much heat; hence it is employed in cooling-apparatuses and in making ice. Water dissolves 600 volumes of the gas at ordinary temperatures, forming NH_4HO. This hydroxid readily parts with its NH_3, especially on warming, and hence is known as the volatile alkali.

Experiment.—With red litmus-paper moistened with H_2O and held in neck of bottle, show volatility of NH_4HO, and notice that red color is restored on drying.

Saturate blotting-paper with alcoholic solution of hematoxylon, dry and hold over a solution which, on warming, gives off NH_3, turning the paper blue. This is a very delicate test.

NH_4HO is official in two strengths: aqua ammoniæ (sp. gr., 0.958), containing 10 per cent., by weight, of NH_3; and aqua ammoniæ fortior (sp. gr., 0.897), of 28-per-cent. strength. Spiritus ammoniæ aromaticus is an alcoholic solution containing ammonium carbonate and ammonia water, flavored with oils of lemon, lavender and nutmeg.

$Ca(HO)_2$ is a white powder slightly soluble in H_2O, forming liquor calcis, or lime water (0.15 per cent.). It is less soluble in boiling than in cold water. Glycerin or sugar renders it much more soluble: 8 grains per ounce. Lime water is used extensively in medicine as an antacid remedy, and is an effective chemic antidote in mineral-acid poisoning. Milk of lime is an aqueous mixture with more $Ca(HO)_2$ than will dissolve in the water. When $Ca(HO)_2$ is exposed to the air it changes to the carbonate by absorption of CO_2; hence the setting of mortar into plaster—also due partly to the formation of a silicate with the sand.

$Ba(HO)_2$ is obtained by treating BaO with H_2O. It is soluble in 20 parts of H_2O, forming the strongly alkaline test-fluid known as baryta-water, which is clouded by the least trace of CO_2. Mg $(HO)_2$ is very slightly soluble in H_2O, with which it forms a gelatinous mixture ("milk of magnesia"—1 to 15 of H_2O), but is freely soluble in solutions of NH_4 salts. $Zn(HO)_2$ is a white ppt. formed by the addition of KHO or NaHO to a solution of a zinc salt. It dissolves readily in excess of reagent, forming a zincate.

$Au(HO)_3$, auric acid, is a yellow-brown ppt. prepared by heating a solution of $AuCl_3$ with magnesia and washing ppt. with dilute HNO_3. When treated with excess of NH_4HO an explosive brown or green powder, known as fulminating gold (perhaps $Au_2O_3.2NH_3$), is produced. Potassium aurate, $KAuO_2.3H_2O$, appears in small, soluble, yellow needles of alkaline reaction, used in gilding Cu.

$Cu(HO)_2$ is a light-blue, bulky ppt., partly reduced to black CuO on boiling. When NH_4HO is added to solutions of cupric salts a deep-blue color results, owing to the formation of ammonio-copper compounds [$CuSO_4(NH_3)_4$ and others]. $Al(HO)_3$ is an insoluble, white powder much used as a mordant. In the presence of more positive oxids $Al(HO)_3$ may act as a weak acid, forming aluminates.

Lead oxyhydroxid [$Pb(HO)_2,PbO$] is readily soluble in excess of precipitating caustic alkali, forming plumbates (K_2PbO_2, Na_2PbO_2), which on boiling throw down red or yellow lead oxid. $Mn(HO)_3$ is a dark-brown substance obtained by atmospheric oxidation of white $Mn(HO)_2$, and is used in varnishes.

$Fe(HO)_3$ is a reddish-brown gelatinous mass or magma, pptd. from ferric chlorid or sulphate by the addition of an alkaline hydrate. When dissolved in ferric-chlorid or ferric-acetate solution and then separated from the crystalloid substances by dialysis, it is known as dialyzed iron, and is usually employed in a 5-per-cent. aqueous mixture. Both this and the ordinary freshly prepared hydrate are effective chemic antidotes for As. $Fe(HO)_3$ gradually changes to oxyhydrate, $Fe_2O(HO)_4$.

SALTS.

In most cases a salt can be prepared by dissolving the carbonate of the metal in the proper acid, filtering or decanting solution and evaporating to point of crystallization. The color of salts is often due to their metallic ions. The therapeutic effects of salts of the alkali metals depend chiefly on their relation to osmosis. The physiologic action of inorganic salts is electric in nature, due to changes in their ions. Salt ions in the blood alter the distribution of fluids in the tissues and exert besides a stimulating effect (diuresis) upon the kidneys. They "flush" the system by increasing the excretion osmotically of the diffusible constituents of the cells. Slowly dissociated salts are comparatively free from local irritative properties. Osmotic nutritive changes produced by drugs are most pronounced in cells of the lowest vitality, hence salt action in general (iodids particularly) tends to break down pathologic formations. Bivalent salts (Sr, Ca) are more slowly dissociated and absorbed than those of the alkali metals; they are less irritant locally and less effective in the blood than the latter. NH_4 salts are excreted as urea; hence (except the benzoate) they do not affect the reaction of the urine. Ca salts lessen the phosphates in the urine (reducing its acidity) by forming insoluble phosphates in the bowel.

The heavy metals have no chemic action on or in the body until changed by air to an oxid (Hg) or by secretions to chlorids, carbonates and other salts. These cations (and Al) combine with proteins (irritant or corrosive action), and are absorbed to a slight degree from the small intestine in such combinations and by the leucocytes. They are excreted mostly by the large bowel (causing irritation and ulceration) and to a less extent through the kidneys and in the secretions (Hg in saliva). Double salts and organic compounds do not combine with proteins (non-irritating) until decomposed, as by acids. Inorganic Fe may be more readily absorbed than food-iron enveloped in colloid matter. The soluble salts of Hg are more irritant and corrosive than those of other metals, since the protein ppt. is looser and so does not protect the deeper layers, and is moreover soluble in excess of proteins or in solutions of neutral salts. The chlorid and nitrate (univalent anions) are particularly penetrating and corrosive. The halogen salts of the alkali metals owe their salty taste and medicinal properties chiefly to the negative element. Aside from their general salt action, they exert a selective influence on different tissues. Cl and Br replace H in its combinations with proteids. The various salts of the body are probably in definite ionic combination (not reacting to ordinary tests), and it is possible to substitute one class of ions for another in the molecule, as when common salt in the food of epileptics is replaced with bromids and the body becomes saturated with Br.

HALOID SALTS.

General Characters.—Mostly white; saline, sharp, or bitter taste; neutral reaction; cubic crystals mostly; less often octahedra or rhombohedra; freely soluble in water (except Ag, Pb, and Hg^I), much less so in alcohol (deliquescent soluble); chiefly binary compounds; ternary salts unstable.

CHLORIDS.

These are usually formed by dissolving a metal or its hydrate or carbonate in HCl. All chlorids except the alkaline and earthy are decomposed, when heated in a current of H, into HCl and the pure metal. $AuCl_3$ and $PtCl_4$ are decomposed by simple ignition.

Next to water NaCl (common salt) is the most abundant compound in Nature, being present in all natural waters and soils and to a slight degree in the atmosphere. It is a necessary ingredient of the fluids of animals and plants, and is obtained chiefly from the salt-wells of New York, Kansas, Ohio and Michigan and the Great Salt Lake in Utah.

Rock salt lies in strata deposited from the sea by evaporation, often covered with strata of the more soluble K, Mg and Ca chlorids and sulphates. A saturated solution contains 2.8 parts in 100 of water. A "normal" saline solution is of the same percentage as the blood,—namely: 0.6 per cent. (0.75 per cent. for cells),—and is used by injection into the rectum, under the skin, or into a vein as a restorative measure in cases of hemorrhage, shock, or collapse. NaCl, having a low molecular weight, and being readily dissociated, induces greater osmotic changes than most other salts. It penetrates the red blood-cells with difficulty, if at all, and differs from most other binary salts in disturbing equilibrium toward the negative side (stimulating). Concentrated solutions act as counter-irritants (saline baths), while drinking large amounts of a weak solution cause a mild stimulation of the gastric mucous membrane. Hypoisotonic solutions are absorbed rapidly, though not so quickly as water or alcohol; hyperisotonic solutions draw water from the blood (hydragog action) until they become isotonic, when the greater part remaining is absorbed. Salt is not essential for the absorption of enemas. The crackling of table salt on heating is due to vaporization of the inclosed drop of salt solution.

The chief sources of potassium compounds are sylvite (KCl) and carnallite ($KCl,MgCl_2.6H_2O$), mined at Stassfurt, Germany. Carnallite is such a weak compound that on dissolving in a small amount of water some of the KCl separates in the solid form.

NH_4Cl is prepared by saturating the ammoniacal liquor from gas-works with HCl, evaporating to dryness, and subliming the residue as feathery crystals. It is used extensively as an expectorant and in calico-printing, dyeing, and soldering, and as a flux in refining gold. The aqueous solution of NH_4Cl is faintly acid, owing to a slight hydrolysis with liberation of H; the acidity is increased by boiling. This splitting off of HCl accounts for the use of NH_4Cl as a metallic flux and as the exciting salt in batteries.

The common packing for steampipes consists of iron filings, S and NH_4Cl moistened with water. It swells and seals the joint hermetically.

$CaCl_2$ is very hygroscopic (soluble in 1.5 H_2O), and the fused or anhydrous product is much used in drying gases and in the quantitative estimation of H in organic bodies. The hydrous compound $CaCl_2.6H_2O$ when mixed with powdered ice or snow makes an effective freezing-mixture. Its ready solubility renders it of service for raising the b.p. of H_2O in the water-bath: a 50-per-cent. aqueous solution boils at 112°. A saturated solution (antifreezine) is used in gasolin automobiles in place of water.

$BaCl_2$ is important mainly as the reagent for H_2SO_4 and soluble sulphates, with which it forms the very insoluble $BaSO_4$. $MgCl_2$ is found in sea-water and mineral waters and carnallite beds, and is a frequent impurity in table-salt. It is used in the manufacture of artificial stone and for finishing cotton goods in dye-works. $ZnCl_2$ is soluble in three-tenths of its own weight of water. It is very corrosive, even attacking cellulose, and is used as a caustic and in weak solutions as an antiseptic, astringent, and deodorant; also by tinsmiths (flux for solder) and embalmers (soft injection fluid) and to preserve wood. The official liquor contains 50 per cent. of the salt. $ZnCl_2$ in fused caustic stick is used to transfix cancerous tumors.

$HgCl$, the mild chlorid, or calomel, is prepared by treating any mercurous salt with HCl. It is a white, odorless, tasteless, and impalpable powder, insoluble in all ordinary solvents. Calomel volatilizes without first melting, and is the salt used for mercurial fumigation. It turns black on the addition of any hydrate, being changed thus to the corresponding oxid. The mild chlorid of mercury, in the presence of the free HCl of the gastric juice, is not transformed into the poisonous corrosive chlorid. HgCl with NH_4OH yields NH_2HgCl, Hg and NH_2Hg_2Cl (mercurous chloramid).

$HgCl_2$ (corrosive sublimate) is obtained by treating any other mercuric salt with HCl or a chlorid. It appears in white crystals, which are odorless, but have a sharp, metallic taste and an acid reaction. On being triturated it remains pure white, whereas calomel turns of a yellowish tinge. $HgCl_2$ is soluble in 16 parts of cold water, 2 of boiling water, 3 of alcohol, 4 of ether, and 14 of glycerin. The aqueous solution slowly decomposes in the light, reacting with the water as follows:—

$$2HgCl_2 + H_2O = 2HgCl + 2HCl + O$$

The addition of a weak acid or of NaCl or NH_4Cl serves to hinder this chemic change; these other chlorids also aid the solubility (forming double chlorids) of the mercurial salt and make it less irritating but less antiseptic. The bichlorid of Hg coagulates albumin (NH_4Cl prevents), and is a popular antiseptic in the strength of from 1-10,000 to 1-1000. It should never be used to sterilize instruments, as it rapidly corrodes them, the metal uniting with one atom of Cl, calomel being deposited on the surface. The "white precipitate" produced by treating $HgCl_2$ solution with NH_4HO is used in ointments (official strength, 10 per cent.).

$FeCl_3.6H_2O$ is a yellowish-red, deliquescent salt prepared by dissolving the oxid in HCl. The official liquor contains 29 per cent. of the salt. The tincture is about one-half the strength of the liquor, being diluted with 3 volumes of alcohol, which reduces ferric chlorid to the ferrous state. The corrosive action of tincture of iron on the teeth is due to the presence of free HCl in this preparation, and patients should be cautioned to rinse out the mouth after taking it through a glass tube. AgCl is used in photographic printing papers. This salt on melting, then cooling, forms a dark-brown mass like horn ("horn-silver").

$AuCl_3.2H_2O$ is a ruby-red crystalline compound forming double salts with HCl and NaCl. $AuCl_3.NaCl$ is prepared by rubbing together equal parts of the dry salts. It appears in orange-yellow, deliquescent prisms used in medicine and dentistry, in gilding, and as a toning agent in photography.

$PtCl_4$ appears in soluble, reddish-yellow needles, obtained by dissolving Pt in aqua regia and evaporating the HNO_3. It is used as a reagent for the quantitative estimation of K, NH_4 (forms double chlorids), and alkaloids.

$AlCl_3$ is used somewhat in weak solutions as a disinfectant. It is very hygroscopic and is used in organic synthesis for uniting H and Cl.

$SnCl_2.2H_2O$ occurs as white needles. It is employed as a mordant in dyeing and calico-printing, and is also a strong reducing agent, precipitating As, Hg, and Au as metals from solutions of their salts. $SnCl_4$ is a fuming yellow liquid forming crystals with one-third as much water, and much used as a mordant for madder-red colors—gives "body" to colored fabrics. A solution of $SbCl_3$ is used extensively for giving a bronze surface to iron and steel: gun-barrels, for instance—and in farriery. Radium chlorid (or bromid) is the form in which the metal Ra is usually employed, and is extracted from pitchblende by repeated treatment with acids and alkalies.

Identification of Chlorids.—$AgNO_3$ in presence of HNO_3 gives a curdy, white ppt., insoluble in boiling HNO_3, but instantly soluble in dilute NH_4HO (1 to 20). A double soluble salt is formed, $AgCl, 3NH_3$ or $2AgCl, 3NH_3$. AgCl also forms a double soluble salt, $NaAgS_2O_3$, with $Na_2S_2O_3$.

CHLORATES.

$KClO_3$ and $NaClO_3$ occur as colorless, shining, monoclinic prisms with a cooling, saline taste. On heating they give off O with deflagration. Violent explosions may result when rubbed with S or dry organic substances. Owing to their oxidizing action, they are largely employed in calico-printing and the manufacture of anilin black. The K salt, soluble in 16½ parts of H_2O, is used as a detergent healing wash in disorders of the mouth and throat and in the manufacture of parlor matches, explosives and flashing powders. $KClO_3$ is manufactured by electrolysis of solutions of KCl.

Experiment.—To solution of $KClO_3$ add enough indigo solution to render distinctly blue; then a few drops of H_2SO_4. The blue color vanishes. Why?

Identification of Chlorates.—Same reaction as chlorids after heating solid to redness and dissolving residue in water, or after adding Zn and dilute H_2SO_4 to solution.

HYPOCHLORITES.

$Ca(ClO)_2$ is met with chiefly in chlorinated lime: a bleaching and disinfecting powder which contains also $CaCl_2$ and is prepared by passing Cl gas over slacked lime. NaClO occurs only in solution as liquor sodæ chloratæ, which should contain 2.4 per cent. of available Cl. Its disinfectant action depends both on the Cl and the nascent O. Hypochlorites liberate free Cl rapidly on addition of acids, and slowly, but spontaneously, on exposure to air, heat, and light through a reaction with CO_2.

$$Ca(ClO)_2.CaCl_2 + 2CO_2 = 2CaCO_3 + 2Cl_2$$

Identification of Hypochlorites.—Odor of Cl. Blue color with KI, starch paste, and acetic acid.

PERCHLORATES.

When $KClO_3$ is heated to 352° it is decomposed into $KClO_4$, KCl, and O. Further heating to 400° breaks up the perchlorate into KCl and O. $KClO_4$ is of no practical importance. Like chlorates, it must be reduced to the chlorid before striking a ppt. with $AgNO_3$.

BROMIDS.

These salts are usually made from Br by combining it with Fe or other metal and then decomposing with a carbonate or hydrate. They have a pungent, saline taste, are very soluble (except Ag, Pb, and Hg^I) in both water and alcohol, and exert generally a sedative action on the nervous system. On heating they fuse and volatilize, with liberation of Br. They are also decomposed by sulphuric and nitric acids. All bromids are changed to NaBr in the stomach. They may cause considerable diminution of the urinary phosphates, by depressing mental activity. The skin eruptions from bromids and other salts probably depend on the irritation accompanying their excretion through the cutaneous glands. The official salts are KBr, NaBr, NH_4Br, LiBr, $CaBr_2$, $ZnBr_2$, and $SrBr_2$. AgBr is used largely in photography, with gelatin on glass or celluloid plates, and is more sensitive to light than AgCl. AgBr is made by the reaction between NH_4Br and $AgNO_3$, the ppt. being washed. It is reduced to subbromid on exposure in the camera. The process of reduction is completed by immersion in a developing solution ($FeSO_4$, pyrogallol, potassium ferro-oxalate, etc.), the untouched AgBr being washed away ("fixing") with sodium thiosulphate. The lights and shadows are reversed in the negative.

Identification of Bromids.—$AgNO_3$ gives a dirty-white ppt., insoluble in HNO_3, slowly soluble in NH_4HO, but insoluble in dilute (1 to 20) NH_4HO.

An aqueous solution, well shaken in a long tube with Cl water and a few drops of chloroform, yields a yellow-brown color, soon settling to a red stratum.

HYPOBROMITES.

These are analogous to the corresponding chlorin compounds. They are very unstable, and hence should be used fresh. They are decomposed by heat, leaving a bromid. NaBrO is a useful reducing agent in the estimation of urea in urine.

BROMATES.

These insoluble salts are of analytic interest only. $KBrO_3$ accompanies KBr as an additional product of KHO and Br_2. It is reduced to bromid by heating with charcoal. If present in a bromid, a yellow color (Br) is produced on addition to the salt of dilute H_2SO_4.

IODIDS.

These salts are made directly from the element, and constitute our most valuable alteratives. Being deliquescent, they are soluble in alcohol. KI is dissolved by ¾ its own weight of water, 18 parts of alcohol, or 2½ glycerin. Given largely diluted in water, it is a standard remedy for tertiary syphilis and in the treatment of chronic metallic poisoning. It appears to combine with these poisons accumulated in the tissues so as to render them soluble, and thus hasten their elimination. NaI is very similar to the K salt, but milder in action.

Because of its volatile alkali, NH_4I is of special service in chronic lung troubles. It is also the principal constituent of tincture of iodin decolorized with ammonia. The salts mentioned appear in cubic crystals, but $SrI_2.6H_2O$, also official, occurs in hexagonal plates, and ZnI_2 in octahedra. The pearly, micaceous crystals of CdI_2 are used by photographers in iodized collodion. AgI is a heavy, amorphous, yellowish powder, soluble in an aqueous solution of KCN or KI, and has considerable use in photography.

HgI is a bright-yellow, insoluble powder, darkening to green on exposure to light, owing to decomposition into metallic Hg and HgI_2. HgI_2 is a scarlet, amorphous powder (sometimes octahedral), soluble in 130 alcohol, and almost insoluble in water unless KI is also present. It is extensively prescribed in the mixed treatment of syphilis, being formed here by reaction between KI and $HgCl_2$. PbI_2 is a very slightly soluble, heavy, lemon-yellow powder used in ointments and plasters. It is distinguished from $PbCrO_4$ by being soluble in NH_4Cl solution on boiling.

There are three iodids of As, of which AsI_3 is official. It appears in brilliant, orange scales, soluble in 12 parts of water or 30 of alcohol. Liquor arseni et hydrargyri iodidi contains 1 per cent. each of this salt and HgI_2.

BiOI has been utilized to some extent as a substitute for iodoform. FeI_2 oxidizes so readily on exposure to air (becoming insoluble) as to require protection with about four times as much sugar of milk (ferri iodidum saccharatum). Syrupus ferri iodidi contains 5 per cent. of FeI_2.

Identification of Iodids.—$AgNO_3$ gives a light-yellow ppt., insoluble in both HNO_3 and NH_4HO.

Starch solution and a few drops of Cl water give a blue color; destroyed by excess of Cl.

IODATES.

The iodates, like the chlorates, are unstable compounds and ready oxidizers. They are of no practical interest. KIO_3 is formed along with KI when I_2 is added to KHO, and is reduced to iodid by heating with wood charcoal. To detect KIO_3 present as an impurity in KI add tartaric acid and starch paste, getting a blue color. The periodate may be prepared by passing Cl into a mixture of KI and KHO.

FLUORIDS.

CaF_2, or fluorspar, is a common rock, used extensively as a flux in metallurgic operations. Cryolite, a double fluorid of Al and Na, is of importance as a source of metal Al, as is also Al_2F_6, formed by passing HF over heated alumina. Finely powdered fluorids warmed gently with a little H_2SO_4 liberate HF, which etches glass, as described under the latter acid.

NITRO-SALTS.

General Characters.—Unstable; explosive; ready oxidizers; anhydrous; white; neutral or nearly so; cooling, saline, pungent taste; soluble (except basic) in water, not in alcohol; deflagrate on heating; refrigerants, diuretics, diaphoretics, and vasodilators. They occur in Nature commonly as an efflorescence on walls or soils wherever organic matter is undergoing decomposition with evolution of NH_3, which oxidizes under the influence of nitrifying ferments into HNO_2 and HNO_3, and these unite with earthy and alkaline mineral matters. Artificially they are made by dissolving a metal in HNO_3. On heating they evolve O and NO_2, leaving an oxid of the metal.

NITRATES.

KNO_3 is used in medicine, fireworks, the refining of gold, and as a meat-preservative along with boric acid. borax, and Na_2CO_3. Ordinary gunpowder is ¾ KNO_3 and about ⅛ each S and charcoal. The products of its combustion are CO, CO_2, SO_2, N, K_2S, etc. $NaNO_3$ occurs naturally as an abundant deposit in the dry regions of South America, where it has been formed by oxidation of NH_3 in the soil, derived from guano. It is very deliquescent, and is used chiefly as a fertilizer; also as a meat preservative and as a source of HNO_3 and KNO_3. NH_4NO_3 is utilized largely in the production of the mild anesthetic N_2O. $Ca(NO_3)_2$ is a very deliquescent salt, soluble in both water and alcohol. $Ba(NO_3)_2$ is an essential ingredient of formulas for pale-green fires. $Sr(NO_3)_2$ is used in pyrotechnics because of the brilliant-red color it imparts to a flame.

$AgNO_3$ is the most important medicinal salt of silver. It appears in colorless, transparent, tabular, rhombic crystals, soluble in 0.6 water or 26 alcohol. It is used chiefly for its cauterant, styptic, or astringent effect upon diseased mucous membranes. In contact with animal matter $AgNO_3$ breaks up into metallic Ag, which stains, and free HNO_3, to which the caustic properties are due. It is used further in hair-dyes, indelible inks, and photography. The fused-nitrate stick, or lunar caustic, contains a little AgCl to toughen it. The mitigated stick is made by melting together 1 part of $AgNO_3$ and 2 parts of KNO_3.

The nitrates of Hg are prepared by dissolving this metal in HNO_3, the product being mercurous or mercuric according as the metal or the acid is in excess. $HgNO_3.H_2O$ is of interest as being the only soluble mercurous salt; but in the presence of much water an insoluble basic compound is formed. $Hg(NO_3)_2$ is official in the liquor and the ointment, and is used in carotting skins for felt hats.

$Pb(NO_3)_2$ appears in large octahedra, soluble in 2 parts of water. It is used in the manufacture of mordants for dyeing and calico-printing. $Cu(NO_3)_2.3H_2O$ occurs in deep-blue, deliquescent crystals that are highly corrosive. Bismuth subnitrate $(BiO)NO_3.H_2O$, is a heavy, white, tasteless, insoluble powder (mineral acids dissolve it readily). Like the subcarbonate, it is used for its local sedative effect; also as a cosmetic and in staining glass and glazing porcelain. Ferrous and ferric nitrates are used in dyeing. The nitrate ion produces local irritation of mucous membrane.

Identification of Nitrates.—Mixed with a solution of $FeSO_4$ in presence of H_2SO_4, a black coloration is produced, due to NO absorbed by ferrous salt, which is changed to ferric sulphate on heating, with disappearance of color.

One drop of phenyl-sulphuric acid (1 part of carbolic acid, 4 parts of H_2SO_4, 2 parts of H_2O) added to salt or residue evaporated over water-bath yields a reddish color, due to nitrophenol.

A solution of diphenylamin, $NH(C_6H_5)_2$, in H_2SO_4 gives a deep-blue color with nitrates; pyrogallol yields a deep-brown color, on sliding conc. H_2SO_4 down the side of the test-tube.

NITRITES.

KNO_2 and $NaNO_2$ are prepared by reducing the corresponding nitrates by heating with Pb or Cu. They are light yellowish in color, very soluble in water, and mostly soluble in alcohol, which is used to separate nitrites from nitrates. The Na salt is the essential constituent of spirit of nitrous ether, and is also employed in the manufacture of colors. NH_4NO_2 is formed in the atmosphere during thunder-storms. $CO_2(NO_2)_6.6NaNO_2$ is a delicate reagent for K salts, showing as little as 0.04 per cent. The nitro-compounds owe their vasodilator activity to the NO_2 ion.

Identification of Nitrites.—Red fumes, when treated with strong H_2SO_4.

Dark-brown color with $FeSO_4$ without previous addition of H_2SO_4.

Instant blue color with KI and starch paste on adding a few drops of H_2SO_4, which liberates nitrous acid.

$$2HNO_2 + 2HI = I_2 + 2H_2O + 2NO$$

THIO-SALTS.

General Characters.—Usually white, and acid in reaction (hydrosulphids alkaline); give off sulphurous or sulphuretted odors when heated or treated with mineral acids; mostly insoluble, except the alkaline salts and a few others. Any compound containing S responds to hepar test, which is to fuse substance on charcoal with Na_2CO_3 and KCN by means of blowpipe. The sulphid thus formed, when placed on a silver coin and moistened with dilute HCl, causes a black stain of Ag_2S.

SULPHIDS.

These are of little medical interest, though of extremely abundant occurrence in Nature. All are insoluble in water except those of K, Na, Ca, Ba, and Sr. Sulphids are very weak salts, decomposed even by carbonic acid. They are recognized by evolving H_2S when heated with HCl, the former acid being readily detected by its odor and characteristic reactions. A delicate test for soluble sulphids is the transient purple color produced by sodium nitroprussid. Sulphids insoluble in HCl form sulphates on heating with strong HNO_3 or nitrohydrochloric acid. Polysulphids—K_2S_3, for instance—are known by the deep-yellow or orange color of their solutions, and by evolving H_2S with deposition of S on treating with HCl or dilute H_2SO_4. PbS is reduced by heating with iron nails. The sulphids of Ag, Sn, Cu, Bi and Sb are readily reduced by passing dry H over them at a red heat.

CS_2 is a colorless, volatile liquid (sp. gr., 1.268) with an ethereal or fetid odor. It is prepared by passing vapors of S over red-hot coals. It is soluble in alcohol, ether, chloroform, and oils. The vapor is very inflammable, and acts as a depressant poison when inhaled. CS_2 is a powerful solvent of rubber and oils (used to extract seeds and animal refuse), S, P, and I, and an efficient insecticide. On account of its great refractive properties, it is used to fill the hollow glass prisms of the spectroscope.

Potassa sulphurata is a mixture of polysulphids with K_2SO_4 and $K_2S_2O_3$. Calx sulphurata is a crude CaS, and is phosphorescent in the dark. Luminous paint is made by mixing S and oyster shells. Its phosphorescence is due to slow oxidation of the CaS to $CaSO_4$.

HgS occurs as a black variety and two red ones, used in paints, namely: cinnabar formed by sublimation of black HgS, and vermilion, made by stirring and subliming 1 part S with 7 parts Hg. Vermilion is used to redden the rubbers for artificial dentures. It is sometimes adulterated with red lead, Fe_2O_3, As_2S_3, brick dust and other reddish substances, which may irritate the gums. Pure vermilion in dental rubbers should not be decomposed by the saliva. MnS when hydrated is pink; on standing it dehydrates into green MnS.

SnS_2 is a gold-colored scale compound used for bronzing wood and gypsum. PbS is a black powder used for glazing pottery. As_2S_2 is employed as a red coloring agent in leather manufacture and in the preparation of white or Indian fire (2 parts with 7 S and 24 KNO_3). Amorphous Sb_2S_3 is used occasionally as an emetic and more frequently in vulcanizing caoutchouc, giving to this a reddish-brown color. FeS, obtained artificially by fusing together Fe (filings) and S, serves in the laboratory as the source of H_2S. FeS_2, the native pyrites, is of immense importance as the chief source of H_2SO_4 and $FeSO_4$. CdS is a yellow pigment used by artists. Ag_2S (argentite, or vitreous silver) is found in Nature in dark-gray, regular crystals, and the so-called oxidized silver is ordinarily prepared by coating with a thin layer of Ag_2S, obtained by heating together Ag and K_2S. NH_4SH, the sulphydrate or hydrosulphid, is obtained by saturating water of ammonia with H_2S till a portion of the liquid ceases to cause a white ppt. with $MgSO_4$ solution. It is a colorless liquid, becoming yellow on exposure to the air, owing to formation of higher ammonium polysulphids and free S. The neutral compound $(NH_4)_2S$ is formed by adding to the NH_4SH solution excess (an equal volume) of NH_4HO. Both compounds are valuable reagents in analytic group work of the heavy metals. $Ca(SH)_2$ is known only in solution and is used as a depilatory.

SULPHATES.

The sulphates are bitter salts found in sea and salt-lake waters and many minerals. They are generally soluble in water (except Pb and alkaline earths), but insoluble in alcohol. They are used in medicine as hydragog cathartics and astringents. Sulphates, phosphates, tartrates and citrates are less readily absorbed than the univalent salts of the same metals; hence they exert osmotic pressure in the bowels. Mg, being bivalent, is more slowly absorbed than univalent Na, therefore $MgSO_4$ is more purgative than Na_2SO_4, though $MgSO_4$ is largely changed to the acid carbonate and Na_2SO_4 in the bowel. The fluid, drawn by osmosis from the blood-vessels, by its weight and the distension of the large bowel causes increased peristalsis and evacuations which are much more prompt than those from vegetable purgatives, most of the salt appearing in the feces. The more concentrated the solution of salts and the more fluid in the tissues, the more profuse the evacuations will be. Ca salts would probably be aperient were they not so readily pptd. The astringent action of lime water is thought to be due to the formation of insoluble compounds with surface proteids.

$Na_2SO_4.10H_2O$ is employed in glass manufacture. $(NH_4)_2$-SO_4, prepared by saturating ammoniacal-gas liquor with H_2SO_4, and evaporating, is the basis for the manufacture of other NH_4 salts, and is a constituent of artificial manure. In addition to extensive medical employment, $MgSO_4$ is utilized as a finisher in dyeing and calico-printing.

$CaSO_4.2H_2O$, or gypsum, is an abundant rock, which, when burnt at 115° so as to lose about three-fourths of its water, and then ground, is known as plaster of Paris. This is a fine, white powder much used by artists (for casts), surgeons (for splints), and dentists (for molds) by reason of its "setting" with water, which is taken up as water of crystallization, expanding slightly and forming the stone-like gypsum again. The finer the powder, the more quickly it sets. Borax, common salt, K_2SO_4, and other compounds quicken this process by facilitating osmosis. The K salt or alum and gelatin or varnish give a polished surface to the dry plaster. Under various trade names plaster of Paris is used for giving a hard finish to plastered walls. Both hydrated and dehydrated gypsum are soluble in dilute acids and in syrup. Gypsum is also used as a fertilizer and cement, and the artificial salt (pearl-hardening, or annaline) is employed as a filling for writing paper.

Experiment.—Prove presence of water of crystallization in gypsum by heating a lump of this and noticing moisture on sides of tube and loss of crystalline appearance.

$BaSO_4$ is a heavy, very insoluble compound used to give weight to cards and paper and as a pigment in water-colors, under the name of permanent white, since it does not blacken with atmospheric H_2S. It is used with alum in making artificial marble.

The sulphates of the heavy metals are generally astringent, owing to the SO_4 radical being combined with not very positive metals. $ZnSO_4$ is an effective irritant emetic, and is used in finishing cotton goods. $CuSO_4.5H_2O$ occurs in large deep-blue, triclinic crystals, soluble in 2.6 parts of water, used as an astringent, as a mordant, in electrotyping, and in gravity batteries. $CuSO_4,4NH_3.H_2O$, made by adding excess of NH_4HO to solution of $CuSO_4$, is used as a styptic and as a test for As. The yellow subsulphate of mercury, $Hg(HO)_2SO_4$, is a nearly insoluble powder sometimes employed as an emetic.

The alums are double sulphates comprising an alkaline and a sesquisulphate (Fe, Mn, Cr, Al) and 12 molecules of water of crystallization. Common, or potash, alum [$KAl(SO_4)_2.12H_2O$] forms large, colorless, efflorescent octahedra having a sweetish and strongly astringent taste and soluble in 10½ parts of water. It is much used as a mordant in dyeing, calico-printing, and in the form of "lakes" for pigments.

Experiment.—Show insoluble lake formed by adding Na_2CO_3 and saturated alum solution to a cochineal solution, and note how the supernatant liquid is decolorized. The acetate is usually employed, the acetic acid being driven off by heat, leaving the hydrate.

Alum loses all its water of crystallization (45 per cent.) on heating to 200°, leaving dried, or burnt, alum, which is much less soluble than the hydrous salt, and is mildly escharotic because of its avidity for water. Ammonia alum [$Al(NH_4)(SO_4)_2.12H_2O$] has the same appearance and properties as potash alum and is somewhat more soluble. Al may be replaced by other metals, forming ferric alum [$Fe(NH_4)(SO_4)_2.12H_2O$], manganese alum, or chrome alum. Soda alum is much used as the acid element in cheap baking-powders. This practice is reprehensible, since a part of the salt changes in the stomach into phosphate and hydrate of Al, both of which are soluble in the gastric juice, and the continued use of such baking-powders leads to chronic dyspepsia and nervous disorders. Hot alum solutions make a good "pickle" for dissolving borax glass from metals after soldering.

$MnSO_4.4H_2O$ appears in rose-colored crystals, soluble in an equal weight of water. It produces a permanent brown dye. $FeSO_4.7H_2O$ occurs as large, light-green, efflorescent crystals, soluble in water, but not in alcohol. It is found in Nature in ferruginous mineral waters. It is used for making ink and as a disinfectant. It destroys organic matters by abstracting their O. $Fe_2(SO_4)_3$ is a white mass dissolving in H_2O to make a reddish-brown solution of liquor ferri tersulphatis. This is styptic and hemostatic, like the subsulphate: $Fe_4O(SO_4)_5$.

A saturated solution (8 : 100) of nickel ammonium sulphate is used in electroplating. The plus pole should consist of metallic Ni, and it is best to copper-plate the steel first. The double sulphate of Fe and NH_4 is employed for the electro-deposition of iron to face copper plates.

Identification of Sulphates.—$BaCl_2$ produces a white ppt. of $BaSO_4$, insoluble in boiling water (if reagent crystallizes out, this dissolves) and also in boiling HNO_3. Insoluble sulphates (Ba, Sr, Ca, and Pb) must first be boiled with KHO or NaHO, or be ignited with an alkaline carbonate and the blowpipe on a piece of clean charcoal.

SULPHITES.

These are usually prepared by passing gas from burning S into solution of a hydrate, forming acid or normal salts, according to the relative amount of the reagents. They are unstable salts, gradually changing to sulphates on exposure to the air; act as reducing agents; and are decomposed by heat (some into oxids and SO_2, others into sulphids and sulphates). The alkaline sulphites are soluble; all others insoluble. Na_2SO_3 gives off the strong reducing agent SO_2 in the stomach. Sulphites and hyposulphites are absorbed and eliminated as sulphates, having a salt action only in the tissues. $NaHSO_3$ is used in solid form and in solution as a preservative and a bleaching agent. This, like all sulphites, evolves SO_2 without deposition of S on heating with acids. $CaSO_3$ is used as a preservative by cider-makers, and the same salt in excess of H_2SO_3 is employed by brewers. Benzoinated Na_2SO_3 has been utilized by dentists as a deodorant.

Identification of Sulphites.—$BaCl_2$, added to a neutral solution, gives white ppt. of $BaSO_3$, soluble in dilute HCl.

Ag_2SO_3 darkens on boiling, owing to decomposition into H_2SO_4 and metallic Ag.

THIOSULPHATES.

$Na_2S_2O_3.5H_2O$, the commercial "hyposulphite," is soluble in two-thirds of its own weight of water, but insoluble in alcohol. It is used extensively in photography, under the name of "hypo," to dissolve the unaltered halogen compounds of Ag. It is also employed to remove the excess of Cl in bleaching and paper-manufacture and in lixiviating silver-ores.

Identification of Thiosulphates.—Dilute or strong HCl or H_2SO_4 drives off SO_2 and produces a yellow deposit of S. The liquid turns green on adding $K_2Cr_2O_7$.

HYPOSULPHITES.

$NaHSO_2$, the true hyposulphite, is used in dyeing and to reduce indigo and in the estimation of free O in the laboratory. The hyposulphite of Ag and of Na is very soluble, and does not coagulate albumins nor stain the skin.

CARBON SALTS.

General Characters.—Carbonates and bicarbonates are usually white and generally alkaline, because of the weak acid radical. Carbonates are generally insoluble, except alkaline; bicarbonates of alkalies and alkaline earths are soluble. Bicarbonates are formed by passing excess of CO_2 into carbonate solution. Carbonates are generally prepared by passing CO_2 into solution of hydrate or by double decomposition of a soluble carbonate and soluble salt of the base. Both give off CO_2 on treating with acids, which dissolve them; the bicarbonates also on simple heating above 50°. Bicarbonates tend to break down spontaneously into CO_2, H_2O, and carbonates, which, being less soluble, form sediments and deposits.

CARBONATES AND BICARBONATES.

K_2CO_3 is derived from wood-ashes, fermented beet-roots, molasses, sheep's wool, carnallite, and kainite. It is soluble in a little more than its own weight of water, but insoluble in alcohol. $Na_2CO_3.10H_2O$ is found in the ashes of all plants, especially those growing near salt water and in the Caspian and other seas. It is commonly manufactured in Europe from NaCl and H_2SO_4 by the Leblanc process, the resulting sulphate or salt cake being reduced to sulphid with C in a revolving furnace, and at the same time caused to react with limestone. This crude soda, or black ash, is used in bleaching, soap-making, and the manufacture of green glass. Purification is effected by lixiviation, evaporating the concentrated solution, and crystallization. The ammonia-soda process is preferred in the United States. It consists in running common salt solution through NH_3 gas and then through a saturated solution of CO_2. The resulting sparingly soluble $NaHCO_3$ is converted into normal carbonate by heat. Na_2CO_3 is soluble in 16 H_2O or 1 part glycerin, but is insoluble in alcohol. It is of great importance as the base from which many other sodium salts are prepared. $NaHCO_3$ is employed in textile industries for its alkaline effect in scouring wool and ungumming silk. It is a component of most baking-powders, being combined in these with starch and some compound with an acid reaction, preferably $KHC_4H_4O_6$. In presence of heat and moisture the two opposing salts react to liberate CO_2, which raises the dough and renders the baked loaf light and porous.

$$NaHCO_3 + KHC_4H_4O_6 = KNaC_4H_4O_6 + CO_2 + H_2O$$

The dried $Na_2CO_3.H_2O$ of the U. S. P. should contain at least 85 per cent. of the anhydrous salt. Impure Na_2CO_3 is the most common constituent of dry chemic fire extinguishers, which also contain sometimes Na_2SO_4 and CaF_2.

The official ammonium carbonate is a compound acid ammonium carbonate with ammonium carbamate, and has the formula $NH_4HCO_3.NH_4NH_2CO_2$. It appears in hard, striated masses, with ammoniacal odor and sharp, saline taste. When exposed to air it loses both NH_3 and CO_2. A solution of the normal salt for reagent purposes is obtained by adding NH_4HO (prevents absorption of CO_2 and

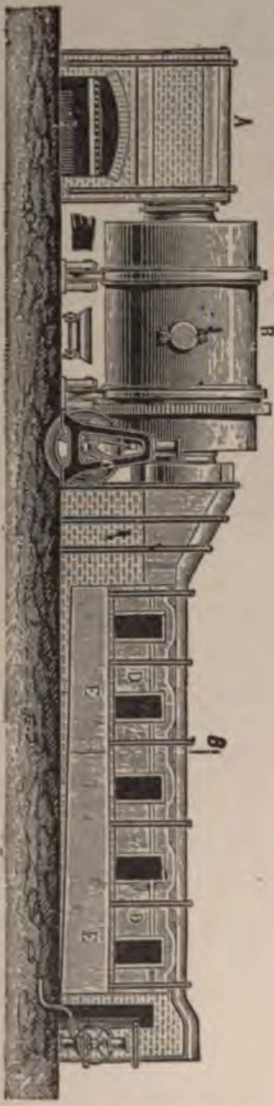


Fig. 29.—Revolving Black-ash Furnace.

formation of bicarbonate). Aromatic spirit of ammonia is a solution of normal carbonate in diluted alcohol, flavored with essential oils (lemon, nutmeg, lavender).

Li_2CO_3 requires 80 parts of water to dissolve it. It is used medicinally as a uric acid solvent. $CaCO_3$ is prescribed as an antacid, chiefly in the form of native chalk prepared by elutriation. Precipitated chalk is formed by the reaction between Na_2CO_3 and $CaCl_2$. It is non-crystalline, and is used in tooth-powders. Whiting and Paris white are impure forms of chalk used as polishing agents. Common putty is a mixture of whiting and linseed-oil. $BaCO_3$ and $SrCO_3$ are used as bases for the preparation of other salts.

Magnesia alba $[(MgCO_3)_4Mg(OH)_2.5H_2O]$ is prepared by boiling each in 80 parts of water 10 parts $MgSO_4$ and 12 Na_2CO_3; the solutions, mixed in the cold, are then boiled for fifteen minutes and strained. It is a loose, white, bulky mass, odorless, and of an earthy taste; practically insoluble in H_2O, but dissolved readily by dilute acids, with active effervescence, giving off 761 volumes of CO_2. It is also quite soluble in NH_4Cl solutions. It is used as an antacid, and is cathartic in the presence of acids. The heavy carbonate of the British Pharmacopeia is prepared by mixing the above reagents each in 20 parts of H_2O and evaporating to dryness.

The official zinc carbonate is an amorphous, impalpable, pale pink-brown powder of inconstant composition, which is usually expressed as $2ZnCO_3.3Zn(OH)_2$. Almost totally insoluble in water and alcohol, it dissolves readily in dilute acids, carbonated waters, and ammonium hydrate and carbonate. Ag_2CO_3 differs from other carbonates in being yellow and turning black on exposure to air and light. Malachite and azurite, the native basic carbonates of Cu, are green and blue, respectively, and are used for ornamental purposes. Hg_2CO_3 and basic mercuric carbonates are unimportant light-yellow and brownish-red salts.

White lead, or basic lead carbonate $[(PbCO_3)_2Pb(OH)_2]$, manufactured from lead by exposing it to the simultaneous action of air, CO_2, and vapors of acetic acid, is of immense industrial importance as the basis of most paints, for which purpose it is ground with 7 per cent. linseed-oil or turpentine and often variously colored. The basic bismuth carbonate $[(BiO)_2CO_3.H_2O]$ is a white powder used in medicine for its antacid and local sedative effect, being quite insoluble in water. Official $FeCO_3$ is protected from atmospheric oxidation by admixture with sugar.

Identification of Carbonates and Bicarbonates.—They effervesce with any acid, except H_2S and HCN, giving off a colorless, odorless gas which turns lime-water milky. Soluble carbonates give a white ppt. with cold solutions of $MgSO_4$; bicarbonates not. $HgCl_2$ gives a reddish-brown ppt. with carbonates of K, Na, and Li; a white ppt. with their bicarbonates.

CARBIDS.

The chief carbid of interest is CaC_2, lustrous, dark-brown, hard, brittle masses, prepared by heating in an electric furnace a mixture of lime and coal or coal-tar. It is important as being the source of acetylene-gas. Carborundum, SiC, is made in the electric furnace from carbon, salt and sand at about 3500°. It occurs in dark-green iridescent crystals, which are nearly as hard as the diamond, and is used as a polishing agent.

SULPHOCARBONATES.

These salts resemble carbonates in constitution, but contain S in place of O.

PHOSPHO-SALTS.

General Characters.—Usually white; efflorescent; cooling, saline taste. Alkaline phosphates, phosphites, and pyrophosphates soluble in water, but not alcohol; others soluble in dilute acids. Hypo-salts all soluble, unstable when in solution—usually protected by sugar. Phospho-salts act chiefly as laxatives and mild biliary stimulants, except hypo-salts, which are used erroneously as a medium for the administration of P. Hypophosphites are excreted unchanged in the urine, and there is no reason to suppose that they have any further action than other indifferent salts, such as chlorids of the same metals (Cushny).

PHOSPHATES, OR ORTHOPHOSPHATES.

These are prepared by neutralizing (or a little more) H_3PO_4 with a hydrate or carbonate. Three classes of salts are formed according as 1, 2, or 3 H atoms of the tribasic acid are replaced by the metal; 2 atoms are always replaced when the acid is neutralized by a carbonate. Trisodic phosphate, $Na_3PO_4.12H_2O$, is alkaline in reaction. On exposure to air it absorbs CO_2, forming Na_2CO_3 and disodic phosphate. This latter, $Na_2HPO_4.12H_2O$, is the official and commercial phosphate of sodium, and is the salt on which the alkalinity of the blood depends largely. It is slightly alkaline to litmus, but not to phenolphthalein. It appears in large, monoclinic prisms, soluble in 5.8 H_2O, but insoluble in alcohol. At half a red heat it changes to the pyrophosphate:—

$$2Na_2HPO_4 = Na_4P_2O_7 + H_2O$$

The alkaline reaction of Na_3PO_4 and Na_2HPO_4 is due to HO liberated by reaction with water, similarly to the hydrolyzation of the carbonates of Na.

Monosodic phosphate, $NaH_2PO_4.H_2O$, has an acid reaction, and is the chief source of urinary acidity. Microcosmic salt,

$NaNH_4HPO_4.4H_2O$, on heating gives off water and NH_3 and forms a clear glass (sodium hexametaphosphate) on cooling. Hence it is used in blowpipe analysis. Li_2HPO_4 is noteworthy as being the only insoluble Li salt. According to Doremus, $(NH_4)_2HPO_4$ is the best agent to render fabrics non-inflammable.

$Ca_3(PO_4)_2$ occurs for the most part in the southern United States and West Indies in the phosphate rock made up largely of the bones of prehistoric marine animals. It is dissolved by CO_2 in the soil for the use of plants. It is extracted with HCl and precipitated with NH_4HO. It dissolves readily in solutions of ammonium salts, $NaNO_3$, NaCl, etc. It is prescribed in the syrup of calcium lactophosphate and is also used very extensively as a fertilizer. Acid phosphate or "superphosphate of lime" is a mixture of $CaSO_4$ and $CaH_4(PO_4)_2$, prepared by treating bones or phosphate rock with two-thirds as much, by weight, of H_2SO_4. It is employed in cheap baking-powders and as a fertilizer, being a necessary ingredient of seeds.

Normal magnesium phosphate, $Mg_3(PO_4)_2$, is also found in bones. Ag_3PO_4 is a pale-yellow, amorphous compound. $MnPO_4.H_2O$ is a greenish-gray powder. Ferri phosphas solubilis is an official scale preparation containing $FePO_4$. $Fe_3(PO_4)_2$ is a slate-colored compound turning blue in the air. It has been found in phthisic sputa, in pus, and in disinterred bones.

Identification of Phosphates.—$BaCl_2$ gives white ppt., soluble in acetic and all stronger acids.

Solution of $(NH_4)_2MoO_4$ in HNO_3 (forms molybdic acid) yields a yellow ppt., insoluble in acids, but soluble in NH_4HO. Arsenates give a similar ppt.

$AgNO_3$ gives lemon-yellow ppt., soluble both in HNO_3 and NH_4HO. Uranic nitrate, in presence of $HC_2H_3O_2$, yields a yellow ppt.

PYROPHOSPHATES.

As the name indicates, these salts are prepared by heating orthophosphates to 250°. There are two series, according as 2 or 4 H atoms of the acid are replaced. $Na_4P_2O_7.10H_2O$ is official, and occurs in colorless, transparent, monoclinic prisms or a crystalline powder. $Fe_4(P_2O_7)_3$ is the salt present in the official scale preparation ferri pyrophosphas solubilis.

Identification of Pyrophosphates.—$AgNO_3$ gives white ppt. in neutral solutions, soluble both in HNO_3 and in NH_4HO.

METAPHOSPHATES.

These salts are prepared by heating the ortho-salts to redness. By polymerization five series of salts are formed, viz.: RPO_3, metaphosphate; $R_2P_2O_6$, dimetaphosphate; $R_3P_3O_9$, $R_4P_4O_{12}$; and $R_6P_6O_{18}$, hexametaphosphate. They are of no practical interest. They give the same reaction as that above under pyrophosphates, and, in addition, coagulate albumin.

PHOSPHITES.

They are strong reducing agents, and burn on Pt foil. The general formula of these salts is R_2HPO_3. They are of no consequence. They are distinguished from hypophosphites by yielding ppts. with Ba and Ca hydrates and with $Pb(C_2H_3O_2)_2$.

HYPOPHOSPHITES.

These salts are prepared from the Ca or Ba salt by double decomposition with a carbonate. The hypophosphites are active reducing agents, and should not be rubbed with oxidizing agents for fear of an explosion. When heated in a dry test tube they give off H_3P, which ignites spontaneously with a yellow, phosphorescent flame.

Experiment.—Boil together in solution any hypophosphite and $HgCl_2$, and note ppt., first, of white calomel and then black mercury. KH_2PO_2 is soluble in 0.6 water and in 7.3 alcohol; $NaPH_2O_2.H_2O$ in 1 water or 30 alcohol; $Ca(H_2PO_2)_2$ in 6.8 water, not in alcohol; $Fe(PH_2O_2)_3$ sparingly in water, not at all in alcohol. The official syrup contains the first three salts just mentioned.

Identification of Hypophosphites.—$(NH_4)_2MoO_4$ gives a fine-blue ppt. The reaction is aided greatly by adding a few drops of H_2SO_3.

PHOSPHIDS.

The only phosphid of any importance is Zn_3P_2. It is made by direct union of P and melted Zn, and appears as a gritty, dark-gray powder or minutely-crystalline, friable fragments with metallic luster. It is insoluble in water or alcohol, but dissolves in HCl, with evolution of H_3P. It is a convenient medium for administration of P.

BORATES.

Orthoborates, from H_3BO_3, are very unstable. The metaborates, from HBO_2, are more stable, but of no practical consequence. The pyroborates are very stable. The most important pyroborate is borax, $Na_2B_4O_7.10H_2O$, which is obtained as a sediment from the borax lakes of Persia, Thibet, California (Death Lake), and Nevada (Pyramid Lake). It is a white, prismatic, crystalline, feebly alkaline substance, soluble in 16 parts of water and less than 2 of glycerin; it is insoluble in alcohol. On heating sufficiently borax swells up and loses its water of crystallization, fusing into a glass-like body. Borax beads prepared in this way have a great affinity for oxids, forming double borates, and with the blowpipe give characteristic colors in the oxidizing and reducing flames for certain metals. This avidity of borax for oxids explains its use as a cleansing agent in the processes of welding, brazing and soldering, and as a flux in refining. It is also employed as a preservative and in the manufacture of certain kinds of glass, soap, and enamels. Glycerin or mineral acids liberate H_3BO_3 from borax.

$$Na_2B_4O_7.10H_2O + 2C_3H_5(HO)_3 = 2C_3H_5BO_3 + 2NaBO_2 + 3H_2O + 10H_2O$$

$$C_3H_5BO_3 + 3H_2O = H_3BO_3 + C_3H_5(HO)_3$$

Sodium perborate, $NaBO_3.4H_2O$, is a white powder which, in contact with water, liberates 70 times its own volume of nascent O.

Identification of Borates.—$CaCl_2$, rendered slightly alkaline with NH_4HO, on heating gives white ppt., soluble in $HC_2H_3O_2$.

On rendering solution just acid with HCl, turmeric paper dipped in it turns brownish red on drying, changing to green on moistening with KHO.

ARSENITES AND ARSENATES.

These are very poisonous salts. All but the alkaline are insoluble. The most important is $KAsO_2$ (metarsenite), of which liquor potassii arsenitis is a 1-per-cent. alkaline ($KHCO_3$) solution flavored with compound tincture of lavender. Sodium arsenite and arsenate are used for cleansing in calico-printing. Scheele's green, $CuHAsO_3$, is a common green pigment. Paris green, well known as a pigment and insecticide, has the formula $Cu(C_2H_3O_2)_2,3Cu(AsO_2)_2$.

Of the arsenates, $Na_2HAsO_4.7H_2O$ is used in medicine, liquor sodii arsenatis being a 1-per-cent. solution. It is soluble in 4 parts water and very sparingly in alcohol. It is used in embalming fluids. On fusing arsenic with alkaline carbonates pyro-arsenates, analogous to pyrophosphates, are formed.

Identification of Arsenites.—Yellow ppt. with $AgNO_3$ or with H_2S in presence of HCl; green ppt. with $CuSO_4$. Usual tests for As.

Identification of Arsenates.—React same as phosphates, except that arsenates give a brick-red ppt., instead of yellow, with $AgNO_3$. Insoluble arsenates should be boiled with NaHO, filtered, and the filtrate exactly neutralized with dilute HNO_3 before testing with $AgNO_3$.

ANTIMONATES.

The acid pyro-antimonate of Na ($Na_2H_2Sb_2O_7.6H_2O$) is noteworthy as being the only insoluble compound of this metal. Potassium metantimonate [$2KSbO_3.5H_2O$] is a gummy or crystalline mass prepared by deflagrating Sb and KNO_3, boiling with water, and allowing to evaporate.

Identification of Antimonates.—Strong HCl throws down white ppt. of $HSbO_3$. On adding KI the mixture turns brown, changing to blue with addition of starch paste.

CHROMATES.

These salts are all characterized by being colored yellow, red, or orange. Chromates of the alkalies are soluble; other chromates generally insoluble. They are irritant poisons.

K_2CrO_4 occurs in yellow, rhombic, weakly alkaline crystals, soluble in 2 parts water. On adding acids its solutions turn red, owing to the formation of the dichromate, $K_2Cr_2O_7$. This salt is soluble in 10 water, the solution being acid. It is an oxidizing agent (with H_2SO_4) used extensively in dyeing and tanning and in photography. It is the source of the other Cr compounds.

Na_2CrO_4 and $Na_2Cr_2O_7$ are similar to the K salts, but are more soluble. $PbCrO_4$ is much used in paints under the name of chrome-yellow. Chrome-red is a basic lead chromate, $PbCrO_4,Pb(HO)_2$. $BaCrO_4$ is also employed as a pigment under the name of yellow ultramarine. The soluble chromates precipitate Ba, but not Ca, from solutions.

Identification of Chromates.—$Pb(C_2H_3O_2)_2$ or $BaCl_2$ gives a yellow ppt., soluble in HNO_3, but not in $HC_2H_3O_2$; KHO darkens (green) and dissolves the lead salt.

Treated with excess of H_2SO_4 and shaken up with ozonized ether, a brilliant-blue color appears.

Acids turn chromate solutions orange; alkalies turn dichromates yellow.

MANGANATES.

These are unstable oxidizing compounds, only the alkali salts dissolving in H_2O, forming green solutions. K_2MnO_4 solution on standing (quickly on boiling or adding an acid) changes to permanganate, its color at the same time passing from dark green through blue and violet to red.

$KMnO_4$ appears in dark-purple, metallic, lustrous prisms, soluble in 16 H_2O. It is a powerful oxidizing agent, deodorant, antiseptic, and disinfectant: in neutral solutions giving off 3 atoms of O; in acid solutions 5 atoms from two molecules. The other permanganates are similar to the K compound. Asbestos-paper should be used in filtering solutions of manganates or permanganates.

Identification of Manganates.—Dilute acids change to permanganates with the gamut of colors above mentioned.

Identification of Permanganates.—Purple-red solutions, entirely decolorized by $H_2C_2O_4$.

$$3H_2C_2O_4 + 2KMnO_4 = K_2C_2O_4 + 2MnC_2O_4 + 3H_2O + 5O$$

STANNATES.

Stannic and metastannic acids dissolve in alkalies to form salts known as stannates and metastannates. The most important compound is sodium stannate, or "preparing salts," Na_2-

$SnO_3.4H_2O$, used largely as a mordant in dyeing and calico-printing. The alkaline metastannates, $R_2H_8Sn_5O_{15}$, are also used in dyeing.

Identification of Stannates.—HCl ppts. white gelatinous H_2SnO_3. (See tests for tin.)

ZINCATES AND ALUMINATES.

These soluble salts are formed when Zn or Al is dissolved in an alkaline hydrate. Their respective radicals are $(ZnO_2)^{II}$ and $(Al_2O_4)^{II}$.

TUNGSTATES.

Sodium tungstate, Na_2WO_4, is used in making fire-proof fabrics.

TELLURATES.

The tellurates of K and Na are employed as remedies for profuse sweating.

SILICATES.

The vast majority of soils are of sedimentary origin, chiefly the slightly soluble silicates. The silicates in granite and other primitive rocks, on weathering in air and water, break up into loose soil and soluble alkaline carbonates (necessary to plants) by displacement of their silicic acid by CO_2 through mass action. The researches of the U. S. Bureau of Soils (Whitney and Cameron) appear to show that there is no obvious relation between the chemic composition of soil and the yield of crops, but that the chief factor determining the yield is the physic condition of the soil under suitable climatic conditions. Soil may be considered a culture medium containing a nutrient solution (lime, potash, sulphates, phosphates, nitrates), the solids of which range from 0.5 to 2 parts per thousand. The amount of H_2O initially present in soils varies from 10 to 25 per cent., and a soil normally containing 20 per cent. H_2O will hold twice as much salts in solution as the same or a different soil having but 10 per cent. of water.

Although forming the great mass of the earth's crust, the silicates are not much employed in medicine. Feldspars are fusible silicates of Al and K or Na. These rocks break down into clays, ordinarily colored with Fe (ocher), mixed with $CaCO_3$ (marl) or organic *detritus* (loam). Kaolin, or china clay, is the purest native Al silicate, and has the approximate composition $Al_4(SiO_4)_3.4H_2O$. Topaz is fluoro-aluminum silicate; turquoise, $Al_4(PO_4)_2(HO)_6.2H_2O$. The precious green stone beryl is a silicate of Al and Be.

The best-known artificial silicate is Na_2SiO_3, or soluble glass, liquor sodii silicatis, which is prepared by fusing sand with excess of Na_2CO_3 and running the melted mass into water. It is used for surgical bandages. K_2SiO_3 is also soluble.

Splints of water-glass can be removed with hot water. Fuller's earth is a smooth earth useful as a skin dressing for infants.

Glass is a silicate of various metals. Common glass is a silicate of Ca (renders glass insoluble) and Na. Bohemian, German, or hard, glass is made by heating together in proper proportions lime, sand, and K_2CO_3. It is difficult to fuse, and resists the corrosive action of chemicals; hence is used extensively for laboratory utensils. Crown or soft French window-glass is a Na and Ca silicate, with addition of a little Fe and Al. Bottle glass contains more Fe and Ca and less K. English, flint, or crystal glass is a silicate of K and Pb; it is readily fusible, lustrous, and highly refractive to light, on which account it is chosen for making cut glassware, lenses, and other optic apparatus. The color of colored glass depends on a small quantity of some metallic oxid: Co gives dark-blue; Mn, amethyst; ferrous, bottle-green; ferric, brownish-yellow or black; Ag or Sb, yellow; Cr, greenish yellow; cuprous, ruby; cupric, bluish-green. Oxids of Zn and Sn and $Ca_3(PO_4)_2$ give a white opacity to glass. U glass is bright-yellow with a brilliant green fluorescence.

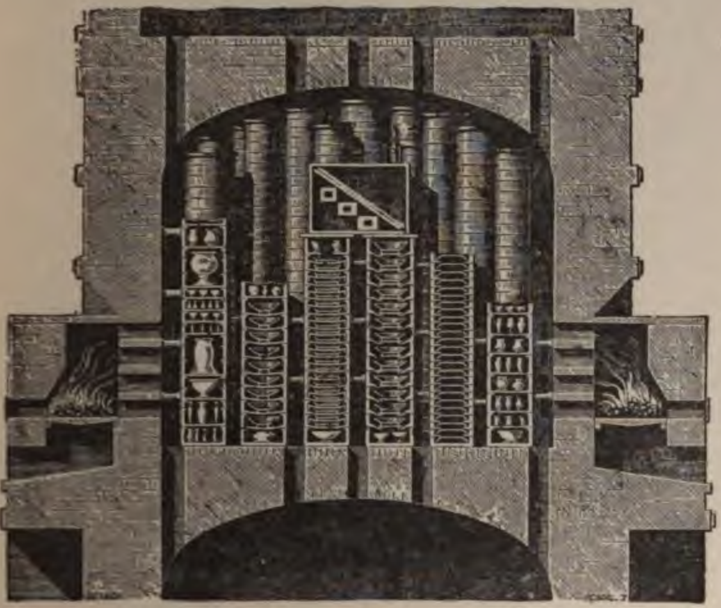


Fig. 30.—Interior of Pottery Kiln.

Pure water dissolves the alkali in glass, and soon shows an alkaline reaction, with deposit of silica. Certain fungi attack glass and cements. Ordinary glass melts at 700°; quartz glass, made by melting quartz in the electric furnace, requires a heat of over 2000° to melt it. Quartz glass expands and contracts hardly at all (hence unbreakable by heat or cold), and transmits freely ultraviolet rays (ordinary glass opaque). The paste of artificial diamonds is made of potash, PbO and ground quartz crystals.

Porcelain is made from a paste of water and kaolin, to which some silica (silex) is added to prevent cracking on drying, and also feldspar to act as a flux and vitrifying cement. The unglazed fired or kiln-burnt product is then dipped into a thin cream of the glaze (same as body, with excess of feldspar to render very fusible), dried, and burned again at a white heat. The porcelain is colored, if desired, with metallic oxids, cobalt-blue, chrome-green, etc.

Dental porcelain for artificial teeth and inlay work contains a relatively large percentage of feldspar, so as to render it more translucent and life-like. The different enamel shades are secured by the use of purple of Cassius, spongy Pt, oxid of Ti (rutile-yellow), or gold and CoO (blue points); for dental uses the silex and feldspar are heated to white heat, plunged into cold water, and ground fine. Kaolin is purified by twice washing, letting settle, and decanting, then drying in the sun.

The dry method of preparing enamel has three steps: 1. Preparing metallic oxid by fusing tin, silver, and gold with borax; removing borax glass; dissolving the silver in HNO_3; washing and drying residue. 2. Fritting, or uniting this powder by heat with a flux of quartz, borax glass, and Na_2CO_3. 3. Diluting frit with sufficient feldspar to secure desired shade.

Stoneware is a coarse porcelain made from clays containing Fe_2O_3 and a little CaO to render somewhat fusible. Glazing may be accomplished simply by throwing into the furnace NaCl, which forms a fusible silicate of Na over the surface of the vessels. The finest earthenware is prepared from white clay mixed with considerable SiO_2 by drying, firing, and dipping into a readily fusible glaze mixture, which often contains PbO; then drying and refiring. Colored designs are printed on paper with oil and enamel pigment and then transferred to the ware before glazing. The oxids of Pb and Sn yield a whitish, opaque glaze, which may be attacked by acids and lead to poisoning.

Kaolin contains about 40 per cent. Al_2O_3 and 46 per cent. SiO_2; the fusible clays used for common earthenware are two-thirds SiO_2 and one-fourth Al_2O_3; fire clays contain a large proportion of SiO_2; brick-maker's clay is about one-half SiO_2 and one-third Al_2O_3. Clays are "acid" or "basic" according to the relative amount of SiO_2 and Al_2O_3. The change caused by heating, from plastic to hard and porous, is due to expulsion of the combined H_2O. True or colloid clay is held in suspension in water indefinitely. It is pptd. by acids, NaCl and compounds of Ca and Mg. Ammonia and alkaline carbonates favor diffusion.

Cements, or hydraulic mortars, are basic silicates of lime and alumina made by burning calcareous clays or cement-rock or suitable artificial mixtures. They "set" much the same as plaster of Paris: by taking up water into combination. On mixing cements with water, $CaCO_3$ and compounds of Ca, Al and Si are formed.

Common, or Roman, cements are derived from clay or rock burnt below the sintering point. Portland cement is such a mixture of limestone and clay or rock as will yield, on burning till sintered, a product containing 55 to 60 per cent. of CaO, 22 to 25 per cent. of SiO_2, and 7 per cent. of Al_2O_3. Concrete consists of hydraulic cement mixed with gravel and crushed pebbles.

Ultramarine is a blue coloring matter consisting of silicates of Na and Al with Na_2S. It is made by heating to redness in fire-clay crucibles a mixture of kaolin, charcoal, and sodium sulphate or carbonate. The resulting green mass is roasted with S till the required shade of blue is obtained. The color is destroyed by heating with HCl, H_2S being evolved. When dry gaseous HCl and air are passed over common ultramarine at 100°-150°, its color is changed to red or violet. Ultramarine has taken the place largely of smalt (cobalt-blue) and Prussian blue, as in wall-paper, calico-printing and painting, also, in dentistry, for taking impressions. The so-called silicate of gold, used in ceramic dentistry to give a yellow tint to porcelain teeth, is prepared by grinding, fusing and regrinding 120 parts of coarse feldspar with 10 parts of gold foil and 8 parts of flux (4 quartz, 1 borax glass, 1 potassium carbonate).

Asbestos, or amianth, is a fibrous silicate of Ca and Mg. It is infusible and a poor conductor of heat. It is used for household utensils, as a fireproof lining material in buildings, and as a non-conducting packing for steam-apparatus and boilers; also, in dentistry, for taking impressions.

Identification of Silicates.—On adding HCl or NH_4Cl to a soluble silicate, nearly transparent gelatinous H_4SiO_4 is precipitated. On drying and heating to 150° and dissolving away chlorids with dilute HCl, SiO_2 is left as a gritty, white powder. Insoluble silicates are first rendered soluble by fusing with 5 parts of mixed K and Na carbonates.

A bead of microcosmic salt ($NaNH_4HPO_4$) touched with the powdered silica or silicate becomes opaque and shows within a floating mass called the "silica skeleton."

ORGANIC ACID SALTS.

General Characters.—Generally soluble, except oxalates; many have characteristic odors, especially on heating or treating with mineral acids; char when heated on Pt (except formates; oxalates turn a little gray) and leave residue of carbonate or oxid; changed mostly to carbonates in blood, rendering this more alkaline and urine less acid. Citrates and acetates have the advantage over carbonates of not neutralizing the gastric juice.

OXALATES.

These salts have an intensely sour taste. The alkaline oxalates are the only soluble ones (BaC_2O_4 slightly soluble), the NH_4 salt being used as a reagent for Ca solutions. $Ce_2(C_2O_4)_3.9H_2O$ is a white, granular, tasteless powder, insoluble except in mineral acids. At red heat it leaves a yellow or salmon mixture of oxids. CaC_2O_4 is often found in urinary sediments and may give rise to concretions. $K_2Fe(C_2O_4)_2$ is a strong reducer, and is used as a developing solution in photography. KHC_2O_4, like the acid, is very poisonous. It is used somewhat to bleach straw and remove ink-stains.

Identification of Oxalates.—$CaCl_2$ in neutral or alkaline solution gives white ppt. of CaC_2O_4, insoluble in acetic, but soluble in hydrochloric, acid.

Dry insoluble oxalates heated in a test tube evolve inflammable CO and leave a carbonate (effervesces with acids).

ACETATES..

These are made by neutralizing carbonates or hydrates with $HC_2H_3O_2$. Neutral acetates are all soluble freely in water and less so in alcohol; basic acetates are insoluble unless a little $HC_2H_3O_2$ is added to form a neutral acetate. Official are the acetates of K, Na, Zn, and Pb; also in the liquors of NH_4, Fe and NH_4 (red), and lead subacetate, $Pb(C_2H_3O_2)_2.PbO$. This last is an effective sedative astringent. The others have generally a diuretic, refrigerant, and alkaline action. The salts of univalent metals cause direct stimulation of the renal cells. They are further diuretic by accumulating fluid in the blood (capillary-engorgement) at the expense of the tissues. K salts are more diuretic than those of Na, since the former react with other salts, producing an excess in the blood of certain salines, which are quickly excreted by the kidneys.

Lead-water, liquor plumbi subacetatis dil., is a soothing lotion made with 40 gm. liquor plumbi subac. in a liter of distilled water. Both these absorb CO_2 on exposure and become milky. $Al(C_2H_3O_2)_3$ and $Fe_2(C_2H_3O_2)_4$ are used as mordants in dyeing under the names "red liquor" and "iron liquor." The former is also employed as a disinfectant and deodorant. The basic acetate and aceto-arsenite of Cu are common green pigments.

Identification of Acetates.—Odor of $HC_2H_3O_2$ when heated with H_2SO_4; apple-like odor of acetic ether on adding alcohol.

Deep-red color $[Fe(C_2H_3O_2)_3]$ with neutral $FeCl_3$; color discharged both by HCl and $HgCl_2$.

VALERATES.

These yield the characteristic odor of valerian when warmed or moistened. The official salts are those of NH_4 and Zn. They are soluble in water and in alcohol.

Identification of Valerates. — Odor of valerian on heating with H_2SO_4; distillate with $Cu(C_2H_3O_2)_2$ solution forms, in time, oily ppt., which gradually solidifies into greenish-blue, crystalline solid.

TARTRATES.

These are important medicinal salts. Soluble tartrates prevent precipitation of ferric and other hydroxids by alkalies, forming soluble salts. $KHC_4H_4O_6$ appears in somewhat gritty, white, rhombic crystals, with acid reaction and pleasant taste. It is sparingly soluble in water and insoluble in alcohol. Because of this fact, it is thrown out of solution as a creamy deposit (cream of tartar) of argols during alcoholic fermentation in wine-casks. It is used largely as the acid ingredient of good baking-powders. $K_2C_4H_4O_6$ is a very soluble, saline purgative. $KNaC_4H_4O_6.4H_2O$ forms large, colorless, slightly bitter, rhombic prisms, with a cooling, saline taste. It dissolves in 1.4 H_2O, and is a useful mild hydragogue.

Tartar emetic, $2KSbOC_4H_4O_6.H_2O$, is a white, crystalline substance, with sweetish, disagreeable taste, quite soluble in water, and slightly in alcohol. It is a depressing emetic, and is used as a mordant in dyeing. Compound syrup of squills contains ¾ grain of this salt to the ounce, and a solution in alcohol and white wine forms official vinum antimonii. Tartrate of Fe and NH_4 and of Fe and K are non-constipating, soluble, garnet-red scale compounds, formed by dissolving $Fe(HO)_3$ in the acid tartrate of NH_4 or K. Seidlitz, or compound effervescing, powder consists of 120 grains of Rochelle salt ($KNaC_4H_4O_6.4H_2O$) with 40 grains $NaHCO_3$ wrapped in the blue paper, and 35 grains $H_2C_4H_4O_6$ wrapped in white paper.

Identification of Tartrates.—Neutral solutions (free from more than a trace of NH_4 salts) give with $CaCl_2$ a white ppt., which after washing dissolves readily in cold KHO, and is again pptd. on boiling.

$Ca(HO)_2$ in excess causes ppt. in the cold, soluble in NH_4Cl when fresh and flocculent.

$AgNO_3$ gives white ppt., turning black on boiling.

Char rapidly on heating to dull redness, and give distinct odor of burning grapes.

$KMnO_4$ solution is decolorized.

CITRATES.

These salts are prepared by dissolving hydroxids or carbonates in $H_3C_6H_5O_7$. All have a cooling taste and are soluble except $BiC_6H_5O_7$ (soluble in NH_4HO). White, crystalline salts include $K_3C_6H_5O_7.H_2O$, $Li_3C_6H_5O_7$, and $BiC_6H_5O_7$. The citrates of Fe, Fe and NH_4, Fe and quinin, Fe and strychnin, and of Bi and NH_4 are scale preparations. $Mg_3(C_6H_5O_7)_2$ is official in the liquor magnesii citratis. This last is made by dissolving Mg carbonate in a slight excess of citric-acid solution, adding syrup of lemon, placing the diluted liquid in a strong, round bottle; dropping in crystals of $KHCO_3$; then corking, wiring, and shaking till crystals are dissolved. It is a mild and pleasant laxative. Elixirs of Bi contain Bi and NH_4 citrate. In nature citrates occur in stone fruits and currants.

Identification of Citrates.—No ppt. in the cold with $CaCl_2$ and slight excess of NH_4OH, but on boiling white $Ca_3(C_6H_5O_7)_2$ is thrown down. When ppt. filtered hot and washed with a little boiling water, it is quite insoluble in cold KHO, but readily soluble in neutral solution of $CuCl_2$ or NH_4Cl_2.

With $KMnO_4$ they yield a green or reddish-green color.

$Ca(HO)_2$ in excess does not cause ppt. till mixture is boiled.

$AgNO_3$ produces white ppt., but no metallic mirror on boiling.

Dry citrates char slowly on heating, giving an acrid odor.

LACTATES.

All are soluble to some extent in water and insoluble in ether. Formerly official were $Fe(C_3H_5O_3)_2.3H_2O$ and $Sr(C_3H_5O_3)_2.3H_2O$. The former appears in sweetish, light-green needles or crusts, and is slowly soluble in H_2O; the latter is a white, slightly bitter, granular or crystalline powder, soluble both in water and in alcohol.

Identification of Lactates.—$AgNO_3$ when boiled gives a dark ppt., which leaves a blue liquid on subsiding.

Strong solutions of alkaline lactate boiled with $HgNO_3$ ppts. pink or crimson $HgC_3H_5O_3$.

TANNATES AND GALLATES.

The salts of tannic acid are bitter, amorphous, and generally insoluble. They are the essential ingredients in nearly all vegetable bitters and astringents (exceptions are columbo, buchu, gentian, quassia, and chiretta). Ferrous tannate is the basis of most black writing-ink.

Identification.—$FeCl_3$ in neutral solutions gives a blue-black ppt. decolorized by $H_2C_2O_4$.

OLEATES.

$KC_{18}H_{33}O_2$ and $NaC_{18}H_{33}O_2$ are the only oleates soluble in water. Acid oleates are all liquid, and soluble in oils, fats, ether, and cold absolute alcohol. The oleates of Hg^{II} and other heavy metals (usual strength 25 per cent.) are used in ointments where penetrating power is desired. They are made by dissolving the oxid in oleic acid. They do not stain linen or become rancid, and seem to exert considerable antiseptic action. Oleates of aconitin, veratrin, morphin, cocain, quinin (25 per cent.) and other alkaloids are formed by simple solution in oleic acid. $Pb(C_{18}H_{33}O_2)_2$, or lead or diachylon plaster, is a white, viscid mass, soluble in ether, and is the basis of the seven official plasters.

Identification of Oleates.—They do not separate from ether or alcohol when a hot solution is cooled. $Pb(C_{18}H_{33}O_2)_2$ is pptd. by $Pb(C_2H_3O_2)_2$, and is almost entirely soluble in ether.

STEARATES.

Alkaline stearates are alone soluble in water. $KC_{18}H_{35}O_2$ is soft soap; $NaC_{18}H_{35}O_2$, hard soap.

Identification of Stearates.—HCl and heat separate free stearic acid, which floats as an oily liquid, and solidifies to a white mass on cooling. $Pb(C_{18}H_{35}O_2)_2$ is insoluble in ether.

FORMATES.

These are all easily soluble in H_2O [except $Pb(CHO_2)_2$ and $Hg(CHO)_2$], and are strong reducing agents. They are of no medical interest.

Identification of Formates.—They decompose, without charring, at a red heat.

Heated with H_2SO_4 they evolve CO, which burns with a pale-blue flame.

SUCCINATES.

These unimportant salts are neutral ($R_2C_4H_4O_4$) or acid ($RHC_4H_4O_4$). Alkaline succinates are soluble; others difficultly or not at all. Succinates are distinguished by giving a bulky, brownish-red ppt. with neutral $FeCl_3$; also with $BaCl_2$ no ppt. at first, but a white one on addition of ammonia and alcohol (distinction from benzoates).

MALATES.

$K_2C_4H_4O_5$ occurs with the free acid in apples, pineapples, currants, and all kernel fruits. The malates are freely soluble. They are recognized by adding $CaCl_2$, which gives no reaction until boiling or addition of alcohol, when a white ppt. is thrown down.

BENZOATES.

These are colorless, crystalline, soluble salts with a slight odor of benzoin. They are chiefly used as urinary antiseptics, being particularly indicated when this fluid is ammoniacal, since the benzoates are eliminated by this route as hippuric acid. Used in medicine are the benzoates of NH_4, Li, Na, Bi, and Hg. They are prepared by neutralizing benzoic acid with the desired hydrate or carbonate.

Identification of Benzoates.—$FeCl_3$ in solution, rendered slightly alkaline with NH_4HO, gives flesh-colored or light-red ppt., soluble in benzoic and other acids.

SALICYLATES.

These are important, white, mostly solid, deliquescent, medicinal compounds with sweetish, alkaline, nauseating taste, made by dissolving alkaline hydroxids in salicylic acid. Their specific curative effect in rheumatism is due in part to their alkaline constitution raising the alkalinity of the blood, and in part probably to a destructive action on the unknown rheumatic germs. The best-known salts are $NaC_7H_5O_3$, soluble in 1.5 water and in 6 alcohol; $Sr(C_7H_5O_3)_2$ and $LiC_7H_5O_3$, also very soluble. The disagreeable taste can be disguised to some degree by giving the salt in some aromatic water: cinnamon or peppermint, for example. $Bi(C_7H_5O_3)_3$ is a white, odorless, tasteless, insoluble powder, used as an internal and intestinal antiseptic and astringent.

Identification of Salicylates.—$FeCl_3$ gives a reddish-violet color, even in very dilute solutions.

Methyl salicylate, formed by warming a salicylate with alcohol and one-fourth the volume of H_2SO_4, is recognized by the odor of wintergreen.

Br water gives a crystalline ppt. with salicylates.

CARBOLATES, OR PHENATES.

Carbolic acid unites with bases to form soluble antiseptic carbolates, which are capable of dissolving large quantities of phenol. NaC_6H_5O appears in fusible, pinkish needles, and is used in dentistry as an astringent, styptic, and disinfectant. Phenol-mercury [$Hg(C_6H_5O)_2$] is a yellow, crystalline substance made by the reaction between an alcoholic solution of NaC_6H_5O and of $HgCl_2$.

Identification of Carbolates.—$FeCl_3$ causes a reddish-violet color. Odor of carbolic acid is evolved on heating alone or with H_2SO_4.

SULPHOCARBOLATES, OR PHENOLSULPHONATES.

When carbolic acid is dissolved in H_2SO_4, sulphocarbolic acid, $C_6H_4OHSO_3H$, is formed, and this on dilution and mixture with oxids, hydrates, or carbonates yields colorless soluble sulphocarbolates. $NaC_6H_5SO_4.2H_2O$ and $Zn(C_6H_5SO_4)_2.H_2O$ are both valuable intestinal antiseptics, the latter salt being also astringent.

Identification of Sulphocarbolates.—Similar reactions as carbolates, but also give reaction of sulphates with $BaCl_2$ after fusing with KNO_3 and redissolving residue in dilute HCl.

MECONATES.

The opium alkaloids occur, for the most part, as meconates ($R_2C_7H_2O_7.3H_2O$). Normal alkaline salts are soluble in water; the acid salts very slightly. Meconates of the heavy metals are soluble in $HC_2H_3O_2$. Meconates are recognized by striking with $FeCl_3$ a red color, not cleared up by $HgCl_2$ or dilute HCl.

PLUMBITES.

$CaPbO_2$ is a soluble crystalline compound formed by reaction between PbO and $Ca(HO)_2$, and is used as a hair dye.

CYANO-SALTS.

General Characteristics.—Generally poisonous, mostly colorless, prismatic; odor of HCN or bitter almonds on wetting or heating with acids; sharp, slightly bitter, alkaline taste; alkaline and alkaline earthy salts and $Hg(CN)_2$ soluble in H_2O, and sparingly or not at all in alcohol (except cyanates). The soluble cyanids dissolve insoluble ones, forming double salts.

CYANIDS.

KCN is a deliquescent compound, soluble in $2H_2O$, used for reduction of metallic oxids, and especially as a solvent of Ag salts in photography and of Au and Ag in electroplating and in the extraction of Au from its ores. KCN is decomposed by the CO_2 of the air, liberating HCN. AgCN and $Hg(CN)_2$ are white powders, turning dark on exposure to light. The isocyanids, isonitrils, or carbylamins are non-toxic liquid hydrocarbon derivatives with an extremely offensive odor.

Barium platinocyanid, $BaPt(CN)_4.4H_2O$, appears in iridescent (greenish-violet) light-yellow crystals. It is used on fluorescent screens for making ultraviolet rays (x and radium) visible.

Identification of Cyanids.—$AgNO_3$ in excess gives a curdy, white ppt., soluble in NH_4HO and in strong boiling, but not dilute, HNO_3; ppt. turns brown on exposure to light.

$CuSO_4$, added drop by drop, gives a rose-pink coloration.

Insoluble cyanids yield $(CN)_2$, smelling like peach-kernels, when heated in dry matrass; draw out open end into jet and light gas, which shows a purple-red flame. The name cyanogen means "generating blue." Why? CN was the first compound radical discovered—by Gay-Lussac, in 1814.

CYANATES, OR ISOCYANATES.

KCNO appears in white scales, and is employed in the preparation of organic compounds. NH_4CNO is a white, crystalline mass, which changes to its isomer urea on heating.

Identification of Cyanates.—On moistening they yield the corresponding bicarbonate and ammonia.

On evaporating with an NH_4 salt, they form urea.

SULPHOCYANATES, OR THIOCYANATES.

$KCNS$, $NaCNS$, and NH_4CNS give a blood-red color with ferric compounds, and are used to distinguish ferric from ferrous salts. $Hg(CNS)_2$ is a white, insoluble powder, which swells up greatly on decomposing by heating, and is used in the cone-shaped toys called "Pharaoh's serpents."

Identification.—On heating with H_2SO_4, HCN is evolved, with characteristic odor, and S is deposited. Also the ferric test mentioned above. The $KSCN$ test for ferric salts is made more delicate by using a conc. solution of this salt and shaking with ether to separate $Fe(SCN)_3$.

FERROCYANIDS.

$K_4Fe(CN)_6.3H_2O$ is manufactured on a large scale by fusing horns, hoofs, leather, etc., with potash and adding iron. It appears in yellow crystals, used in dyeing and in making KCN, HCN, and the pigment Prussian blue, $Fe_4(FeC_6N_6)_3$. Blue ink consists of Prussian blue dissolved in oxalic acid.

Identification of Ferrocyanids.—Any ferrous salt gives a white ppt., quickly changing blue; any ferric salt a dark-blue ppt. of Prussian blue, insoluble in HCl, turned reddish-brown by KHO, the blue color being restored by adding HCl.

Pb, Zn, Ag, and Hg solutions give white ppts.; cupric salts a reddish-brown ppt., insoluble in acids, but soluble in NH_4HO.

FERRICYANIDS.

These salts are produced by oxidation of solutions of the ferrocyanids with Cl. The O is given off in the presence of free alkali, red prussiate of potash $[K_3Fe(CN)_6]$, changing back to yellow prussiate, or ferrocyanid. The ferrocyanids and ferricyanids do not dissociate Fe in the body.

Identification of Ferricyanids.—Any ferrous salt ppts. dark Turnbull's blue $[Fe_3Fe(CN)_6]$, insoluble in acids, decomposing with boiling KHO into $K_3FeC_6N_6$ and dirty green $Fe(HO)_2$.

Any ferric salt gives a brownish coloration, and throws down Turnbull's or Prussian blue on adding reducing agents (H_2SO_3 or $SnCl_2$). Lead and mercuric salts give no ppt.; stannous salts, white ppt.; mercurous solutions, brownish red; $AgNO_3$, orange.

NITROPRUSSIDS.

These salts are formed by the action of HNO_3 on ferrocyanids, NO replacing a CN. The only one of practical interest is sodium nitroprussid $[Na_2Fe(CN)_5NO.2H_2O]$, which appears in red prisms and is used as a reagent.

QUESTIONS ON INORGANIC CHEMISTRY.

Metals.

1. Name the alkali metals and the metals of the alkaline earths.

2. Which is the more potent, KBr or NaBr, and why?

3. If a cubic inch of Fe and a cubic inch of Sn were both heated to the same temperature and placed on a cake of paraffin, which would melt the wax first?

4. What metals decompose H_2O, and why?

5. Write equation for decomposition of H_2O with red-hot Fe.

6. What two metals rank first as conductors of heat and electricity?

7. Why do silver spoons tarnish?

8. How can one separate Hg from other metals?

9. At what temperature does Hg distill?

10. What objection to sterilizing Al instruments by boiling with a soda solution?

11. Why is the solution blue when a silver coin is dissolved in HNO_3?

12. Why should H_2O_2 be measured in a glass graduate?

13. Reasoning from the dose of liquid preparations of As, what should be the dose of solid preparations?

14. When a child is given full doses of a Bi compound, what should one say to the mother about the stools?

15. What is the m.p. of Pb, of Sn, and of soft solder?

16. How does aqua regia dissolve Au and Pt?

17. How distinguish "mystery gold" from true gold?

18. What carat is United States gold coin?

19. What is iron-rust?

20. What is the theoretic m.p. of Wood's fusible metal?

21. Is an alloy of Au and Ag accompanied by expansion or contraction?

22. What is the weight of a cubic foot of Au?

23. Name five natural compounds of Al.

24. Why did the bronze precede the iron age?

25. What are the chief uses of Pt?

26. Compare Al and Sn for domestic purposes.

27. What is the sp. gr. of Al, Cu, Fe, Ag, and Au?

28. Explain the chemic principle of "sympathetic inks."

29. How does Hg produce medicinal effects?

30. Why are Ag salts used in photography?

31. Why does Cu turn green in moist air?

32. How may taking S internally tarnish a silver dollar in the pocket?

33. To what is the color of common rocks due?

34. What are "blacksmith's scales"?

35. How do so many ores occur as sulphids?

36. Why are Fe salts often saccharated?

37. Why are alloys generally preferable to single metals?

38. Why are sand and lime used in the roasting and extraction of metals.

39. What are the chemic differences between wrought Fe, cast Fe, and steel?

40. Why is Sb used in type-metal?

41. Why are Fe retorts used in separating Hg from other metals?

42. Why do dental fillings discolor in the mouth?

43. Why is Fe administered in blood diseases?

44. Why are the alkali metals kept in benzene?

45. Determine the carat of an alloy containing 8 parts Au, 2 parts Ag, and 2 parts Cu.

46. How much pure gold must be added to 10 gm. of 18-carat gold to raise it to 22-carat?

47. How could you reduce 10 gm. of pure gold to 14-carat?

48. Why does a weak KCN solution dissolve Au better than a strong solution? (The weak solution absorbs more air.)

Metalloids.

1. What is the most abundant element in Nature?
2. What is the valence, atomic weight, and density of H?
3. What are the chief uses of O in Nature?
4. Give the derivation of five elements named after some physic property?
5. How could you prove the presence of H in any compound?
6. What simple gas can be collected by upward displacement, and which by downward displacement?
7. How detect decomposition of Cl water into HCl?
8. What element is noted for its unstable compounds?
9. Describe the chief chemic interrelation between plants and animals.
10. To what is the luminosity of P in H_2O due?
11. What is the principal source of P and its compounds?
12. Sound travels four times as fast in H as in O. Why?
13. How does Cl destroy the odor of sewer-gas.
14. State the density and molecular weight of ozone.
15. Name six chief components of the atmosphere.
16. How is air liquefied?
17. What difference between atmospheric air and that absorbed by H_2O?
18. What danger of lead poisoning is there from chewing lead-pencils?
19. Describe three allotropic forms of C.
20. Why is it harder to light a fire of coke or hard coal than one of soft coal?
21. Write equation for formation of S in Nature.
22. For what two poisonous metals has H a great affinity?
23. Name the halogens.
24. What is the chief source of Br?
25. Why are C and Zn used in batteries?
26. How many times as much H is liberated by 1 gm. Mg as by 1 Gm. Zn?
27. What is vulcanized rubber?
28. Why is a partly burned match black?
29. Why is a good draught needed for a good fire?
30. How does charcoal deodorize?
31. Why does a lamp-chimney smoke when the wick is turned low or too high?
32. How does Cl bleach?
33. Why does H prepared from commercial Zn always have an odor?

Oxids.

1. What fractional part of H_2O are O and H, by weight and by volume?
2. Why does boiled H_2O taste flat?
3. Why is rain-water purer than that from ponds or rivers?
4. What are anhydrids?
5. Distinguish between deliquescent and efflorescent substances.
6. How does boiling soften water?
7. How does washing-soda soften water?

8. To what is the color of most crystals due?
9. Why is natural water never pure?
10. How can one make fire from water?
11. How can one prove that water is a product of fire?
12. What are the chief uses of BaO_2?
13. What advantage in using H_3PO_4 or H_2SO_4 rather than HCl in preparing H_2O_2?
14. Write equation representing some chemic reaction into which H_2O enters.
15. Why are halogen oxids very unstable?
16. What is the valence of I in its oxid?
17. Why is SO_2 always present in city air?
18. How does S, thrown on the fire in a stove or grate, extinguish the fire in a burning flue?
19. Is CO heavier or lighter than air?
20. What percentage of weight is lost in converting magnesium carbonate into the oxid?
21. How may we render a Mg solution alkaline without precipitation?
22. How does calcining ZnO for dental cements get rid of contaminating As?
23. What is the chemic composition of the black scales on heated Cu?
24. What color does red lead turn on heating, and why?
25. On what does the cauterant action of CrO_3 depend?
26. What makes the stalks of grain stiff?
27. What is a grain of sand, chemically speaking?
28. What is "petrified wood"?
29. Write equation for preparation of laughing-gas.
30. How does lime slake?
31. Why does "soda-water" effervesce?
32. How does SO_2 decolorize objects?
33. What is the chemic fire-extinguisher?
34. Explain how a bottle filled with quicklime and loosely stoppered will break spontaneously.
35. Explain the scaly crust formed on the bottom of a tea kettle or a boiler.
36. What salt is decomposed by atmospheric CO_2?
37. How much water-vapor will be formed by the union of 200 c.c. H and 100 c.c. O?
38. What poisonous oxid may be present in anilin dyes?

Acids.

1. Mention the general characteristics of hydro-acids.
2. What causes the white film on the inside of a bottle of HCl?
3. Write equation for reaction producing the white cloud when the open mouths of a bottle of HCl and of NH_4HO are brought near together.
4. In what part of the human body does free HCl occur?
5. How make official dilute HCl from the strong acid?
6. Show by equation how free Cl is produced in aqua regia.
7. If a cold, dilute solution of starch and KI give a blue color with HCl, what impurity is indicated?
8. What kind of a stain is produced on black cloth by HCl, HNO_3, and H_2SO_4?
9. How does dilute H_2SO_4 act as an astringent?
10. Write equation for reaction of HNO_3 on Cu.
11. Why is HI usually prescribed as a syrup?
12. Show by equations the relations of the acids of P.
13. What weak acid breaks up as soon as formed?

14. What acid is a strong bleaching and disinfectant agent?
15. What is silicic acid?
16. What acid imparts a green color to flame?
17. If a H_2S generator were leaking at some point, how could one determine the point?
18. To what is the bad smell of rotten eggs due? Why do they float?
19. What acid liberates most other acids from their salts?
20. Write equation for a mixture of H_2SO_4 and H_2O.
21. What relation does the percentage of pure HCl bear to the sp. gr.?

Bases.

1. What are the caustic alkalies?
2. What is the density of NH_3? Is it heavier or lighter than air?
3. How could you prepare the hydroxid of any of the metals except of the alkalies and alkaline earths?
4. Calculate how many volumes of NH_3 are required to make a 10-per-cent. solution, by weight, in H_2O.
5. Explain appearance of white scum on lime water exposed to the air.
6. Why is $Ca(HO)_2$ nearly twice as soluble in cold as in boiling water?
7. What is "milk of magnesia," and for what is it used?
8. What hydrate is used extensively as a mordant?
9. How make "black wash" and "yellow wash"?
10. What is dialyzed iron?

Salts.

1. How can one remove the purple stain of $AuCl_3$ from the hands?
2. Reason out a method for removing $AgNO_3$ stains from the skin.
3. What are the products resulting from heating $KClO_3$?
4. Represent, by an equation, the action of vinegar on chlorinated lime.
5. Explain the color-change in identification of hypochlorites.
6. Which official bromid contains the greatest percentage of Br, and hence is most hypnotic?
7. Explain color-change and use of chloroform in Cl test for bromids. What would a violet color indicate?
8. What amount of KI is required to make a saturated aqueous solution?
9. Why is sugar used with the licorice-root in pil. ferri iodidi?
10. Explain why the protiodid of Hg is sometimes yellow in color, sometimes green.
11. How detect the contaminating presence of red lead or Hg in vermilion?
12. How would you prepare a solution of $Ca(SH)_2$?
13. Explain setting of plaster of Paris.
14. How much $ZnSO_4$ will 10 gm. Zn yield?
15. What change in appearance of white lead and of Bi subsalts on heating (200° or more), and why?
16. How detect adulteration of white lead with $BaSO_4$?
17. Why is good baking powder preferable to saleratus?
18. Write equation for raising of bread with baking powder.
19. Why cannot $NaNO_3$ be used in gunpowder?
20. What should be the color of a mixture of bromid and iodid tested with starch and Cl water?
21. Mention the only insoluble Li salt.

22. What precautions should be observed in evaporating hypophosphite solutions?
23. What colored ppt. does $(NH_4)_2MoO_4$ yield with a mixture of phosphates and hypophosphites?
24. What pigments would you mix to get chrome-orange?
25. Explain ppt. of argols during vinous fermentation.
26. Is FeC_2O_4 soluble or insoluble?
27. What solvents are of aid in removing ordinary plasters from the skin?
28. How does $AgNO_3$ dye the hair?
29. Why is the caustic action of lunar caustic superficial?
30. Why do dental cements give way more rapidly near the gum-margin?
31. Write equation for firing a gun.
32. What salt is formed in making H in the laboratory?
33. What makes some waters hard: temporary and permanent?
34. Why are ternary halogen salts unstable?
35. Give the common name and formula of the chief salt of Sb.
36. What is the chemic nature of glass, and how is it colored?
37. What changes take place in the drying of wall-plaster?
38. What group of metals has the most soluble salts?
39. What is the chief medicinal compound of Mg?
40. What is the "bichlorid of gold"?
41. Write the graphic formula of ferric bromid.
42. What is the chief use of the salts of Sn?
43. From what two localities are Ni and Co ores generally obtained?
44. What is the only medicinal salt of Ce?
45. Explain the use of borax in welding.
46. How does the addition of washing soda, NaOH or lime water soften hard water?
47. How does cement harden under H_2O?
48. Why does a white-painted house turn dark in time?
49. How could you separate traces of $HgCl_2$ from HgCl?
50. How does adding a little sal ammoniac to the water prevent the formation of a fur in boilers?
51. Of what salts are ashes chiefly composed?
52. Write equation for freezing mixture of Na_2SO_4 and HCl.
53. To make a fresh preparation of $NaC_7H_5O_3$, what relative proportions should be used of salicylic acid and sodium bicarbonate?

THE CARBON COMPOUNDS.

THE term organic was formerly applied to compounds derived directly or indirectly from living organisms; all others were called inorganic or mineral. This distinction was first broken down by Henry Hennell, who in 1826 made alcohol from coal-gas; and again in 1828 by Wöhler, who obtained urea by warming ammonium cyanate produced in the laboratory. Since then the synthetic manufacture of drugs formerly prepared only in Nature's laboratory by the supposed "vital force" has risen to immense proportions. As an example of such synthesis, acetylene-gas, C_2H_2, can be made by direct union of C and H in the electric arc, ethylene may be prepared from acetylene by the action of nascent H; and ethyl alcohol is obtainable from ethylene by treating the latter with H_2SO_4 and H_2O. Sugars have been made by simple electrolysis of H_2O charged with CO_2. Ordinarily synthetic preparations are derived from natural products and by-products, particularly coal-tar, which is the source of a great number of dyes and medicines. It will be seen that the term organic chemistry has lost all its former significance, and is now simply a convenient name for the science of the carbon compounds, particularly those which contain this element in a combustible form. Substances which exist naturally in a state of mixture are termed proximate principles.

Test for Organic Substances (that is, for Carbon).—Heat sugar or other C compound on Pt foil till it chars. Keep heating, and it all burns away unless some impurity or a metallic salt of an organic acid is present.

Treat sugar with H_2SO_4 and note the charring, owing to the acid taking H and O, or water, away and leaving the C.

A better test is to mix the sugar with ten times its weight of CuO and heat to redness in a narrow, hard-glass tube sealed at one end, passing the gases (CO_2, etc.) into lime water.

C has a wonderful capacity for uniting with itself and H to form a great variety of compounds. Along with O, these two elements make up most vegetable substances. Animal substances contain, in addition, N and sometimes S and P, Cl and I. No natural compound contains sufficient O for the complete combustion of its combustible elements; such artificial compounds are often explosive. The four elements H, O, N and C are sometimes called organogens.

Test for H.—Heat sugar in a dry test-tube and note cloud of vapor in upper, cooler part of tube.

Test for O.—Show that absolute alcohol oxidizes Na, whereas, benzene, C_6H_6, does not.

$$Na + C_2H_5HO = H + C_2H_5NaO$$

Test for N.—Heat white-of-egg disks on Pt foil, and note odor of burning feathers; or heat in a hard-glass tube with soda-lime (equal parts NaHO and CaO) and mark odor of NH_3.

A more delicate test is to heat a small disk gradually to a red heat in a narrow test-tube with a piece of Na the size of a pea. Allow to cool a little, and break off hot end by immersing in a little water in an evaporating-dish. Then filter off the C; add a few drops of $FeSO_4$, and warm; acidulate with HCl, and test with a drop of $FeCl_3$, forming blue $Fe_4(FeC_6N_6)_3$.

$$6NaCN + Fe(HO)_2 = Na_4Fe(CN)_6 + 2NaHO$$

Test for S by boiling white of egg in an alkaline solution of $Pb(HO)_2$, getting dark ppt. of PbS.

Test for P by fusing yelk of egg on Pt foil with KNO_3 and K_2CO_3 till the residue is colorless. Dissolve this in H_2O, and, after pptg. sulphates with $BaCl_2$, filter and throw down phosphates with $(NH_4)_2MoO_4$ in HNO_3.

We may also oxidize the substance by heating in a sealed tube with HNO_3. H_3PO_4 is formed, and is recognized by the usual tests.

Test chloroform for Cl by mixing it with pure CuO and igniting on Pt wire. Cl (and Br) gives a blue color, changing to green; I a green color. The wire should first be held in the flame till colorless.

The empiric molecular formulas of organic substances are obtained by dividing the percentage of each element by its atomic weight to get the ratio of the elements; then taking as many atoms of each element in these ratios as will make up the molecular weight, which is twice the vapor-density (see "Analytic Chemistry").

Example.—Formaldehyd contains 40 per cent. of C, 6.66 per cent. of H, and 53.34 per cent. of O. These numbers divided, respectively, by the atomic weight of each element give the proportion of 3.33 atoms of C, 6.66 of H, and 3.33 of O, or 2 of H to 1 each of C and O; hence the percentage composition is CH_2O. The vapor-density of formaldehyd is 15; hence the molecular weight is 30, which corresponds with the weight of the molecule CH_2O (12 2 16). The correct formula is therefore CH_2O.

Acetic acid shows the same percentage composition as formaldehyd, but its vapor-density and molecular weight are twice as great; hence its formula should read $C_2H_4O_2$. Again, lactic acid has the empiric formula $C_3H_6O_3$; since, while the elements are in the same proportion as in formaldehyd, the molecular weight is 90 in place of 30.

Organic compounds are separated and purified in three ways: 1. By shaking or boiling with alcohol, ether, benzene, and chloroform, in all of which inorganic compounds are generally insoluble. A mixture of benzoic acid, tartaric acid, and sugar can be separated, the first by ether, the second by alcohol, and the third with H_2O. 2. By crystallization from the various solvents above mentioned. Two or more substances may sometimes be separated by fractional crystallization. 3. By distillation, especially fractional, as in the parting of alcohol and water. The process is sometimes conducted in a current of steam or under reduced pressure. The m.p. of pure substances is always definite; of impure substances indefinite and gradual.

By eremacausis is understood the natural slow combustion or decay of organic substances. Proteins putrefy (through the agency of anaërobic saprogenic bacteria) into bad-smelling, alkaline products. Carbohydrates ferment into CO_2 and other acid products not usually of a bad odor. Produce and meats are best kept at a temperature just above f.p. After freezing, meat, fish and milk lose flavor and spoil more rapidly when exposed to heat. The term humus is applied to the dark (carbonaceous) mixture of decomposing vegetable substances in the soil.

Chemic changes in plants are generally constructive or synthetic by reduction; those in animals, destructive, oxidative, or analytic. Thus, plants build up CO_2 and H_2O into starches and sugars, which are broken down again in the animal organism into H_2O and CO_2.

Plants, like animals, have a selective nutritive power, and take up proportionally more bases (unless there is excess of nitrates) from the soil-solution, leaving an excess of acids in solution. They have been grown to perfection in well water renewed weekly. The rôle of fertilizers seems to be in the main that of a stimulant to early rootlet growth. Vegetable fibers are carbonized by acids, animal fibers are dissolved by alkalies.

Plant principles used medicinally consist chiefly of catabolic products, which serve the purpose of self-protection against bacteria, fungi, insects, worms and larger animals. Because of cheaper production, synthetic preparations are replacing more and more the natural plant derivatives. It suffices to mention in this connection the manufacture of salicylic acid and oil of wintergreen from coal tar; of camphor from turpentine; of valeric acid by oxidation of amyl alcohol; and of codein by methylation of morphin. Much alcohol is now made synthetically.

The roots of medicinal plants contain various alkaloids, glucosids, fixed and volatile oils, resins and starch. The smaller leafy and flowering or fruiting stems of many plants are used in medicine. Tubers are in the main a storehouse of starchy reserve material for the use of the plant in the second year of biennials. Rhizomes likewise, as a rule, contain considerable starch. The outer color of barks depends on lichens. All barks contain much tannin (quercus alba, 7 per cent.; rubus, 20 per cent.), which varies slightly in constitution in different plants. Heart woods often have tannin, resins and coloring matter. The green color of leaves and floral foliage is due to chlorophyl and the closely allied xanthophyl. The coloring matters of flowers are mostly unknown (probably phenol compounds) and are readily decomposed. These colors serve, like the scent, to attract insects to get the nectar (saccharose) and pollen, and so insure cross fertilization. White or pink flowers are turned blue by treating the plant with iron. Plants bloom (Loew) because of stimulation by the sugar in the sap. This saccharine solution is more concentrated when the moisture supplied to the plant is deficient.

Malates, tartrates, citrates, and their free acids (more in unripe), with sugar (replaces starch) and pectin are the chief ingredients of edible fruits. All aromatic umbelliferæ yield volatile oils. Seeds are relatively rich in fats, proteins and alkaloids. The aleuron grains are made up of a globoid body of the phosphates of calcium and magnesium and crystalloid proteids, in a ground substance which is soluble in water.

Climate, season and soil have much to do with the composition (quantitative particularly) of plants. The proportion of any element in a plant can be greatly increased by furnishing its rootlets with a suitable mineral substance. The iron content of spinach has been increased sevenfold by treating the soil around the roots with ferric hydrate. Many volatile oils vary in their constituents according to climate and soil, and even with the part of the plant.

Roots should be gathered at full maturity, just before the flowering period—biennial plants in the autumn of the first year, perennial in the fall of the second or third year. Aconite tubers are usually best gathered in winter or early spring. Barks are to be peeled off in the spring when the sap begins to flow, or in winter. Only the inner layer of the coarser barks is used medicinally. Leaves and herbs should be collected when the plants are in full flower, and should be dried carefully in the shade so as to retain their bright green color. Digitalis leaves should be plucked in the autumn of the second year; they must be used within a few months. Flowers are collected when they first open or just after, and are dried in the shade. Seeds are to be gathered just while ripening, before the seed pods are open, and are winnowed to remove fragments of stems, leaves and shriveled specimens.

Crude drugs and their products used in medicine are generally mixtures of considerable complexity. Thus asafetida contains a dozen chemical constituents. Oil of peppermint consists of at least 15 terpenes. Even the so-called active principles are not always chemical entities. Commercial aconitin is a mixture, in variable proportions, of true aconitin, pseudo-aconitin, aconin, pseudo-aconin, and picraconitin. The crystalline aconitin is about three times as strong as the amorphous, and this is five or six times the strength of the eclectic resinoid aconitin. Fluid extracts represent for each c.c., 1 gm. of the crude drug.

A growing plant is more than three-fourths water, which keeps up a marked tension, and by the partial loss of which the plant wilts. The ash of plants seldom exceeds 3 per cent. (rhubarb sometimes 40 per cent.; 15 per cent. in chondrus), being most abundant in the stem and leaves. Mineral substances in general facilitate chemical reactions. Ca serves the same purpose in the cell walls of plants as in bones; potassium aids in condensing organic molecules. Na is not needed by plants. Silica gives a protective sheath or cutting edge to certain leaves. Buchu ash is rich in Mn. Potassium nitrate is a common constituent of plants (hyoscyamus, tobacco, borage), but the most abundant plant salt is calcium oxalate, which appears in single or multiple (raphides) crystals in many species (most in rhubarb root). Calcium carbonate is found occasionally as "cystoliths," resembling bunches of grapes.

In the disintegration of plants, as in constructive metabolism, the widely distributed ferments (oxidase, diastase, cellulase, lipase, etc.) doubtless play an important rôle. The odor of a plant, as in belladonna and tobacco, is often developed after its collection. A curious phenomenon, not fully understood, is the gelatinization of certain fluid extracts (red gum, hydrastis, kino, catechu) on standing or in contact with oxidizing agents (potassium permanganate).

HYDROCARBONS.

Hydrocarbons are simply compounds of C with itself and H. Of these there are a great number, some of the most important being arranged in the following table. They are, for the most part, vegetable products, directly or indirectly, analytic or synthetic, being built up by plants from the CO_2 and H_2O of the air. They are generally colorless and insoluble in water, but soluble in ether or alcohol; neutral, stable, and volatile without decomposition.

NOMENCLATURE OF HOMOLOGOUS HYDROCARBONS.

PREFIXES.	SERIES I.	SERIES II.	SERIES III.	SERIES IV.	SERIES V.
	Paraffins ($C_nH_{2n}+2$).	*Olefins* (C_nH_{2n}).	*Acetylenes* ($C_nH_{2n}-2$).	*Terpenes* ($C_nH_{2n}-4$).	*Benzenes* ($C_nH_{2n}-6$).
Meth-	ane = CH_4				
Eth-	" = C_2H_6	ene or ylene = C_2H_4	ine = C_2H_2		
Prop-	" = C_3H_8	" " = C_3H_6	" = C_3H_4	one = C_3H_2	
But-	" = C_4H_{10}	" " = C_4H_8	" = C_4H_6	" = C_4H_4	une = C_4H_2
Pent-	" = C_5H_{12}	" " = C_5H_{10}	" = C_5H_8	" = C_5H_6	" = C_5H_4
Hex-	" = C_6H_{14}	" " = C_6H_{12}	" = C_6H_{10}	" = C_6H_8	" = C_6H_6
	Up to $C_{40}H_{82}$				

The arbitrary arrangement given above is designed as a simple plan for designating hydrocarbons according to their exact composition. It will be noted that the prefix ***meth*** indicates 1 atom of C; *eth,* 2 atoms; *prop,* 3; *but* or *quart,* 4; *pent* or *amyl,* 5; *hex,* 6; *hept,* 7, etc., with the use of Greek numerals. It is also seen at a glance that the suffixes indicating the series are in the order of the vowels of the alphabet, and that each member of a series is 2H less than the corresponding member of the preceding series, as shown in a general way by the algebraic formulas. Hence it is an easy matter to deduce the name from the formula, or *vice versâ.* The sixth series is known as the cinnamene; the eighteenth as the anthracene.

Homologous hydrocarbons differ by CH_2, and hence belong to the same series. Isologues differ by H_2, and are corresponding members of adjacent series. Isomeric bodies have the same formulas, but are not physically identic. Polymeric compounds are multiples, the one of the other, *e.g.*, propene and hexene. True isomerism is often indicated by the prefix *iso*; polymerism, by *para.* Metamers are compounds having the same composition, but different constitutions or structural formulas. Examples of metameric compounds are cyanic acid, $N \equiv C-O-H$; isocyanic acid, $H-N=C=O$; and fulminic acid, $C \equiv N-O-H$.

For convenience of study, the C atom is frequently represented as a tetrahedron, and formulas or diagrams based upon this conception are termed stereochemic. Stereo-isomerism

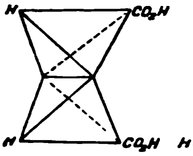


Fig. 31.

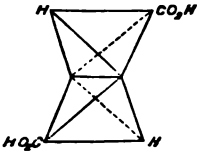


Fig. 32.

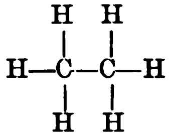
Fig. 31.—Maleic Acid. Plane symmetric (or cis-) form.
Fig. 32.—Fumaric Acid. Axial symmetric (or trans-) form.

(allotropism, enantiomorphism; right and left hand rotation) is the term applied to differences solely in physic properties of certain compounds having the same molecular and constitutional formulas. These variations are accounted for by a difference in the relative positions of the atoms: *i.e.*, the way they face each other. Neutral combinations of stereo-isomeric substances are called racemoid. Thus, atropin is a racemic mixture of dextro- and levo-hyoscyamin.

A change of chemic constitution, as in these carbon compounds, is termed atomic re-arrangement. There are a few substances whose atoms may change position without altering the identity of the molecule. Thus, phloroglucol can be represented as $C_6H_3(HO)_3$ or as $(CH_2)_3(CO)_3$, and is an example of such tautomeric (desmotropic) molecules. All optically active substances contain asymmetric C atoms (sometimes italicized), to each of the four bonds of which a different element or group is attached. The usual formula is called normal or primary, and has 1 C linked to no more than 2 other C atoms. In *iso*, or secondary, compounds 1 C is linked to 3 others; in *meso*, or tertiary, to 4; in *neo*, 2 to 3. The number of possible graphic isomeric formulas for the fourth member of the first series is 2;

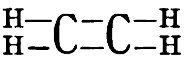
for the fifth, 8; for the eighth, 18, and so on by permutation to 802 for the thirteenth member.

The members of the first four series are comparatively easily broken up, and hence are arranged graphically in open (arborescent) chains, as ethane:—



$$\begin{array}{ccccc} & H & & H & \\ & | & & | & \\ H- & C & - & C & -H \\ & | & & | & \\ & H & & H & \end{array}$$

The carbon nucleus of the fifth series is very permanent, hence is represented as a closed chain or ring. The unsaturated nature of the members of all the series except the first is represented rationally by double or treble bonds or linkings between C atoms, thus, ethene:—



$$\begin{matrix}H-\\H-\end{matrix}C=C\begin{matrix}-H\\-H\end{matrix}$$

Unsaturated hydrocarbons unite readily with halogens and hydro acids to form saturated compounds.

By dropping an H from any of these formulas a monad radical is obtained. Such hydrocarbon, alcohol, or alkyl radicals are electropositive, and are named with the usual prefix, but with the ending changed to yl (occasionally *ylene* or *enyl* when 2 or 3 H are removed). Examples are: CH_3, methyl; C_2H_5, ethyl; C_5H_{12}, pentyl or amyl; C_6H_5, hexyl or phenyl; C_6H_4, phenylene; C_3H_7, propyl or tritenyl; and C_3H_5, allyl. Compounds containing the radicals of the first series are termed *alkyls,* because they resemble the alkali metals in type. Compounds of the fifth series isomeric with those of the first are designated by the prefix *cyclo.*

PARAFFINS, OR FATTY SERIES.

This series differs from the others in its members being saturated; hence, stable. All are neutral, combustible, and lighter than H_2O. The name paraffin indicates "little affinity," or chemic inertness. The first four members of the series are gases; the next twelve, oily liquids at ordinary temperatures; the higher members are fatty and waxy solids. Atmospheric O converts many of the liquids into solids. The members of this series are thought to have originated by destructive distillation of the fatty remains of sea-animals in the lower layers of the earth's crust.

Methane, or "marsh-gas," is a colorless, tasteless, odorless gas formed by decay of vegetable matter under H_2O. It constitutes 90 to 95 per cent. of natural gas and 30 to 40 per cent. of ordinary coal-gas (6 to 12 per cent. of water-gas). It often collects in large quantities in ill-ventilated coal-mines ("fire-damp"), where it may take fire and give rise to terrible explosions.

Experiment.—Prepare pure CH_4 by heating 1 part $NaC_2H_3O_2$ with 4 parts soda-lime, collecting over H_2O. Note blue flame when burned. This is a sign of danger when seen within the Davy safety-lamp of miners.

Ethane is also present at times in natural gas. Butane, or quartane, is a gas which when liquefied (cymogene) is used in ice-machines. Rhigolene is a hydrocarbon mixture (mostly pentane), used as a local anesthetic by evaporation.

Petroleum is an extremely important natural mixture (up to $C_{20}H_{42}$) obtained from wells and furnishing most of the members of this series. In the crude form it is a thick, brown or yellow liquid. Among the products of its fractional distillation (with b.p.) are cymogene (0°); rhigolene (21°); benzin (50° to 60°); gasolin (75°); naphtha (82° to 149°); ligroin, or light petroleum (70° to 120°); cleaning oil (120° to 170°); kerosene, or refined petroleum (150° to 250°); mineral sperm-oil (218°); lubricating oil (301°); paraffin (melts at 45° to 65°); vaselin (soft, melts at 40° to 45°; hard, at 45° to 51°); and coke, or petroleum pitch. All fractions are purified by treating with H_2SO_4, then washing, then rendering alkaline. Some of these compounds are derived from the dry distillation of soft coal, bitumen, shaly wood, ozokerite, and fish-oil. Petroleum compounds are characterized generally by more or less fluorescence. They are soluble in ether, chloroform, CS_2, benzin, benzene, turpentine, and oils.

Benzin, benzolin, or petroleum-ether (mixture of pentane and hexane) has a sp. gr. of 0.66 and is a good solvent for oils, fats, resins, and rubber. It remains semiliquid at —175° It is used to remove grease-spots and for varnishes and paints. Clothing saturated with benzin may take fire in direct sunlight.

Naphtha appears in three forms (A, B, and C), with different b.p.'s. It is the so-called safety-oil, and is used as a solvent for oils, fats, resins, and rubber. Cleaning oil, as the name suggests, is used for cleaning purposes and also in place of turpentine in varnishes. Gasolin is highly inflammable, and is used in special stoves and for running automobiles. Gasolin is given the formula C_6H_{14}. Sufficient heat may be developed by rubbing fabrics soaked in gasolin to cause spontaneous combustion.

Kerosene, or coal-oil, constitutes from 50 to 60 per cent. of average petroleum. It should not "flash" (yield an inflammable gas) below 120° F. or ignite itself under 300° F.

Experiment to Test Flashing-point of Kerosene.—Fit a large test-tube with a perforated cork provided with a bent glass tube and a thermometer. Pour about 15 c.c. of kerosene into the tube, and heat very gradually on water-bath. Agitate surface of liquid at frequent

intervals by blowing through glass tube; then apply a flame to mouth of test-tube, repeating the trial until the flame flashes down into the tube.

Vaselin, cosmolin, or petrolatum, is a mixture of the upper half-series of fatty, yellowish hydrocarbons. It is purified and decolorized by passing through bone-black. Liquid petrolatum (sp. gr., 0.875 to 0.945) is a useful sedative application to mucous membranes. The solid (hard and soft) is used as an ointment-base.

Paraffin (sp. gr., 0.877) is the waxy residue left after distilling off the above-named products. Ozokerite, or mineral wax, consists largely of paraffin, and is used in the preparation of ceresin, a substitute for wax. Paraffin is acted on hardly at all by the strongest chemicals, for which reason it is used on the glass corks of reagent bottles. It is also utilized extensively for candles and in matches, and of late has been employed (along with vaselin) in a melted state by way of injection for cosmetic purposes.

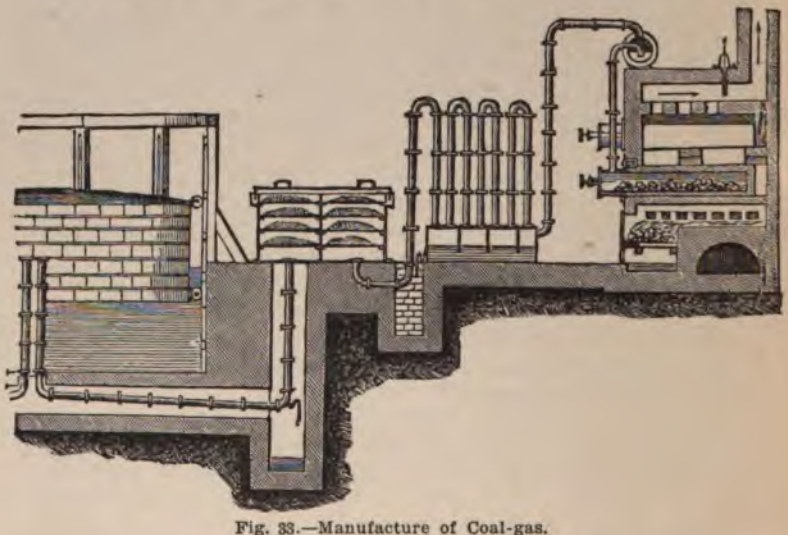


Fig. 33.—Manufacture of Coal-gas.

Photogene and solar oil are distilled from the tar left after the destructive distillation of cannel-coal or shale in the production of paraffin. They are used as solvents and illuminants.

Coal-gas is made by the destructive distillation at bright-red heat of bituminous coal in fire-clay or cast-iron retorts. The gaseous products are passed through the hydraulic main, a series of tubes partly filled with H_2O, where the steam, tar, and NH_3 are condensed; then into the scrubbers (columns of coke over which water trickles); then through a number of large boxes with perpendicularly arranged shelves, where the gas is purified (of H_2S, CO_2, CS_2, SO_2, and volatile oils) with freshly slacked lime, a mixture of sawdust and oxid of Fe, etc.; and thence to the gasometer, a large, tub-shaped, iron storage-vessel, floated upside down on water. A ton of coal yields 10,000 to 12,000 cubic feet of gas. The specific gravity of coal-gas is from 0.65 to 0.75.

Water-gas (producer, or fuel, gas) is made by the alternate action of air and steam on anthracite coal at a red or white heat. The gaseous product is mixed with naphtha-vapor, strongly heated in tubular retorts, and purified as above. Being cheaper, though much more poisonous (four or five times as much CO), it is very largely used for heating and illuminating purposes. The chief ingredients in both kinds of gas are CO (5 to 25 per cent.), H (30 to 50 per cent.), CH_4 (20 to 40 per cent.), C_2H_2, C_2H_4 (4 to 10 per cent.), N, and CO_2.

The by-products in the manufacture of coal-gas are of vast importance, particularly NH_3 and coal-tar. The chief constituents of gas-tar are liquid hydrocarbons (benzol, creosote, toluol, xylol, cumol), solid hydrocarbons (naphthalin, anthracene, chrysene, pyrene, pitch), alkaline products (ammonia, anilins, quinolins, pyridin) and the tar acids (carbolic, cresylic, toluolic, acetic).

Natural gas is chiefly CH_4, with some C_2H_6, C_3H_8, H, etc. It is probably a product of past decomposition of organic matter pptd. from water in stratified rocks and subjected to heat and pressure. The CO_2 of springs and soils may have originated in the same way.

OLEFINS, OR ETHYLENE SERIES.

This series is comparatively unimportant. Its members are prepared by destructive distillation of fats, waxes, coal, and lignite. The first three are gases, the following four volatile liquids, and the sixteenth and higher solids. They are mostly soluble in ether and alcohol, and are readily oxidized by CrO_3 or $KMnO_4$. The principal member is ethylene (C_2H_4), or olefiant gas, so called because it forms a colorless, oily liquid ($C_2H_4Cl_2$) with Cl; this fact also accounts for the name of the series. About 6 per cent. of coal-gas consists of C_2H_4, to which the luminosity is largely due. It has a peculiar, sweet smell. Pentene, or amylene, has been used as an anesthetic under the name of pental. It is obtained by dehydrating amyl alcohol, and has an odor like mustard. The gases of the ethylene group, made by destructive distillation of oil, and compressed in iron cylinders, are used in the Pintsch system of lighting.

ACETYLENES.

This series is so named after ethine, or acetylene, a colorless gas with a sharp, garlicky odor (almost odorless or like geranium when pure), formed by incomplete combustion when a lamp or gas-jet is turned low, or when the flame of a Bunsen burner "strikes back." The peculiar odor of a room heated by an oil- or gas-stove is due mainly to acetylene. It is prepared commonly by decomposition of CaC_2 with H_2O. In the dry process of manufacture CaC_2 is shaken with some powdered substance (soda commonly) containing H and O. One pound of CaC_2 yields 5 cubic feet of C_2H_2.

Experiment.—To some lumps of calcium carbid add water, and light evolved gas.

It has ten times the illuminating power of ordinary gas, and is not so poisonous, but may explode when mixed with air. On heating without air it is converted into benzene (C_6H_6) or styrene (C_8H_8). C_2H_2 is detected by passing the gas into a solution of CuCl in NH_4HO, forming brownish, amorphous, explosive copper acetylid, $C_2H_2Cu_2O$. C_2H_2 under 26 atmospheres at 0° becomes a liquid, said to be the lightest known. Propine is commonly known as allylene and allene (isomeric gases), and butine as crotonylene.

TERPENES, OR TRITONES.

This series comprises most eleoptens or essential oils of plants, used for odor and flavor, and obtained generally by distillation, sometimes by pressure, fermentation, or solution in fixed oils. They leave no permanent stain on paper, being volatile. They are mostly lighter than H_2O, and quite soluble in alcohol, forming essences and spirits (usually 10 per cent. in strength). They are fairly soluble in ether, but in H_2O only to the extent of 1 m. per fluidounce, forming aquæ. Many of them are isomeric or polymeric with pinene or turpentine, $C_{10}H_{16}$, and they tend to polymerize to $C_{15}H_{24}$ or $C_{20}H_{32}$ when heated in a sealed tube or shaken with H_2SO_4. Most volatile oils are optically active. When pure they are colorless (some are green from chlorophyl—others blue, from azylene), but tend to darken with age and to become sticky and resinous. They combine directly with O and HCl; dilute HNO_3 oxidizes them into organic acids. Terpeneless essential oils are oxygenated compounds (lemon chiefly citral and esters of geraniol) to which the flavor and perfume are largely due. They are separated from the terpenes also present naturally by fractional distillation, the latter having a lower b.p.

The active principle of counter-irritants and stimulants is generally a volatile substance; hence, penetrating. Ethereal oils with low b.p's. and comparatively little O are very penetrating; thus, turpentine is more penetrating than mustard or cantharides. Volatile oils are closely related to phenols and aromatic acids. They are all antiseptic and some are germicidal, readily penetrating protoplasm and lessening its vitality by acting as foreign bodies. They are of special service (particularly terebene) as stimulating antiseptics in subacute and chronic stages of inflammation of the urethra or bladder. Volatile oils are excreted chiefly by the lungs and kidneys, and are used as stimulating expectorants (terpin, terebene, balsams, squill). Carminatives (chiefly volatile oils) cause a sensation of warmth and comfort in the stomach and a marked increase reflexly of the gastric juice. They accelerate gastric motility, promote absorption and relieve flatulence and distention. Their effects in the large bowel are best obtained by giving full doses (of asafetida or turpentine, for example) in enemas of hot water and soap.

The crude oil of turpentine, the juice of the pine, when distilled leaves common rosin, which consists chiefly of the anhydrid of abietic acid, $C_{44}H_{64}O_5$. The sp. gr. of turpentine is 0.86. It is a good solvent for resins, paints, S, and P. On exposure to air, like other volatile oils, it absorbs O as ozone, and becomes resinous, which explains its drying action in paints. The acid, or French, turpentine thus obtained is used as an antidote for P poisoning.

Test for Oil of Turpentine.—Heat a few drops with a drop of equal parts of HCl and $FeCl_3$, getting a red color, slowly turning violet, then blue.

Terebene, terpin, and terpinol are valuable medicinal derivatives of $C_{10}H_{16}$. They are stimulants because they are volatile. Terebene is obtained by the action of H_2SO_4 on oil of turpentine and consists chiefly of pinene, $C_{10}H_{16}$. When $C_{10}H_{16}$ is treated with H_2SO_4 white crystals of terpin hydrate, $C_{10}H_{18}(HO)_2.H_2O$, are formed.

Volatile oils may be classified as follows:—

1. True terpenes ($C_{10}H_{16}$ — terebenthene = propylmethyldihydrobenzol): Bergamot, birch, cajuput, chamomile, caraway, dill, hops, juniper, lemon, myrtle, nutmeg, orange, parsley, pepper, rue, savin, thyme, Tolu, turpentine, and valerian.

2. Cedrenes, or sesquiterpenes ($C_{15}H_{24}$): Calamus, cascarilla, cedar, cloves (16 per cent.—mostly eugenol and eugenic acid), cubebs, patchouly, and rosewood.

3. Aromatic aldehyds: Almond and cinnamon.

4. Compound ethers: Mustard (horseradish) and wintergreen.

The third and fourth classes are a little heavier than H_2O. Most essential oils contain also some oxidation products in the form of stearoptens.

Experiment.—Heat moderately a few cloves in a dry test-tube, getting heavy white vapors of the volatile oil, condensing in the upper part of the tube. Pour some of these vapors into another tube, shake with a little alcohol and a drop of $FeCl_3$. Note blue or green color.

The volatile oil of lemon is protected from becoming terebinthinate by mixing with an equal volume of alcohol. Oil of orange flowers in contact with a saturated solution of $NaHSO_3$ gives a permanent purple color. Oil of cajuput and oil of eucalyptus are now assayed (U. S. P.) for cineol; oil of lemon, for citral (same empiric formula as camphor). Sandalwood oil (sp. gr., 0.970) forms a slightly acid solution in alcohol, and consists of an alcohol, $C_{15}H_{26}O$, and an aldehyd, $C_{15}H_{24}O$. Tobacco leaves contain a peculiar flavoring oil. In making mustard papers black mustard seed, previously exhausted of fixed oil with benzin, is made into a paste and spread on paper. The gum resin myrrh contains 2 to 4 per cent. volatile oil, on which its value chiefly depends. Tonka beans contain the odoriferous principle coumarin (also in sweet clover, new mown hay and fenugreek), used in flavoring cheap vanilla extracts.

Volatile oils are prominent constituents of anthemis, cardamom, matricaria, calendula, sambucus, matico, salvia, eriodictyon, senega, stillingia, sumbul, peppermint, spearmint, anise, coriander, star anise, fennel, wormwood, hedeoma, melissa, grindelia, savin, tansy, vanilla, saw palmetto, hoarhound, sassafras, cascarilla and xanthoxylum.

Stearoptens, or camphors, are solid, volatile, oxidized essential oils, therefore insoluble in H_2O, but soluble in alcohol. They melt easily and sublime. They burn with a smoky flame, like all the rest of this series, and are medicinally stimulants. Ordinary camphor (laurinol) has the formula $C_{10}H_{16}O$ (that of Borneo, $C_{10}H_{18}O$). Monobromated camphor, $C_{10}H_{15}BrO$, is made by adding Br to a solution of camphor in chloroform. Menthol ($C_{10}H_{20}O$), from oil of peppermint; thymol ($C_{10}H_{14}O$), from oil of thyme and horsemint; and eucalyptol, 6 per cent. ($C_{10}H_{18}O$), from oil of eucalyptus, are similar to camphor chemically and are characterized by a pleasant odor. Myrtol is derived by distillation from the leaves of Myrtus communis. Anemonin is a camphor derived from pulsatilla. Apiol is parsley camphor. Artificial camphor is prepared by heating turpentine with oxalic acid and distilling the product. The turpentine yields one-fourth its own weight of camphor.

Identification of Thymol.—Dissolve in conc. KHO solution, warm, and add a few drops of chloroform, getting a reddish-violet color.

Caoutchouc (elastica) is a hard, tough polyterpene (chiefly $C_{20}H_{32}$), soluble in CS_2, C_6H_6, chloroform, and ether. When heated with 7 to 10 per cent. of S at 130° to 150° it yields black, vulcanized rubber, which is more elastic and less affected by chemic agents. Hard rubber (vulcanite, ebonite) contains from 20 to 35 per cent. of S. Dental rubber is colored with vermilion, ZnO, $CaCO_3$, and white clay. Rubber plasters have as a basis cleansed and rolled Para rubber with olibanum (true frankincense), purified pitch, etc. When they become brittle and non-cohesive, they can be temporarily restored by warming and wetting with alcohol. Rubber hardened by age can be softened by soaking in dilute NH_4HO.

Gutta-percha is harder and more tenacious, and can be molded in hot water into splints. A solution in chloroform is known as traumaticin, and is used as a dressing for slight wounds. Gutta-percha is also employed by dentists as a plastic non-conducting filling material.

Resins are solid, brittle, amorphous, non-volatile, oxidized essential oils; acid (some neutral) in reaction; soluble in alcohol, ether, and oils; and pharmaceutically incompatible with H_2O. Those which combine with alkalies form soaps.

They occur in Nature mixed with one or more other resins. They give a characteristic brown or yellow color to plant products, and tend to darken with age. They are derived partly from retrograde metamorphosis of tannins, cellulose and starch.

Phlobaphenes, or resinoids, differ from resins in being soluble in dilute NH_4HO or in benzin. They are mostly derived from tannins by boiling with acids. They often constitute the coloring principle (brown) of extracts, and are of no medicinal value.

Oleoresins contain also some unoxidized oil, and are soluble in ether and alcohol. Copaiba is insoluble in ether. Balsams are like oleoresins, with addition of benzoic and cinnamic acids, which give an aromatic odor. Alcohol is their best solvent. Gum-resins are resins plus gum and sugar and up to 9 per cent. of volatile oil. They appear in milky tears, and are best dissolved with dilute alcohol. Rubbed with H_2O in a mortar, they yield good emulsions (asafetida, white; scammony, green; gamboge, yellow). Many members of the above classes are natural vegetable exudations, popularly known as gums.

Examples of Resins.—Rosin, ergotin, guaiac, jalap, pyrethrum, podophyllin, lac (stick, seed, and shell), sumbul, mastic, sandarac, caulophyllin, macrotin (cimicifugin), dammar, copal, amber, and asphalt. The last four are fossil resins. Resins are important constituents of frangula, cascara sagrada, senna, rhubarb, sumbul, pyrethrum, stillingia, leptandra, sanguinaria, and phytolacca. Of the resins of jalap (15 to 20 per cent.), jalapin is soluble in ether; convolvulin, insoluble. The resin acids of guaiac are peculiar in giving striking color reactions: HNO_3, blue-green, passing to red; $HgCl_2$, bluish-green; $FeCl_3$, blue. Arnica owes its properties to a resin and a volatile oil. The bitter, griping resin contained in senna can be removed by percolating the leaves with alcohol. The active principle of cannabis indica is cannabinol, an oily red resin which oxidizes on exposure to air to a black, inactive pitch. The ripe fruit of podophyllum is not purgative (contains no resin).

Examples of Oleoresins.—Copaiba, capsicum, cubeb, lupulin, elemi, pepper, ginger, male fern, crude turpentine, Burgundy and Canada pitches, wood-oil or gurjun balsam, and various turpentines from pine-, fir-, and larch- trees. The medicinal ones are extracted, as a rule, with ether (100 to 150 parts). Wood-tar (pix liquida) is a complex mixture containing methyl alcohol, acetone, paraffin, creosote, pyroligneous and carbolic acids, etc., prepared by the destructive distillation of pines. Oleum cadinum also contains phenols.

Examples of Gum-resins.—Ammoniac, asafetida, myrrh, scammony (up to 90 per cent. of resin scammonin), galbanum, gamboge (with cambogic acid), euphorbium, and olibanum (frankincense).

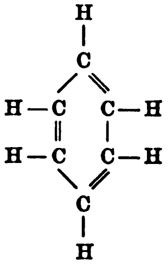
Examples of Balsams.—Benzoin, Peru, copaiba, Tolu, and storax (styrol, C_8H_8). Benzoin is one-eighth to one-fourth benzoic acid. Balsam of Peru consists of resin with benzylic benzoate and cinnamate and some free acids. Çinnamein (oily mixture of benzoate and cinnamate) is separated from the resin by means of benzin. Bálsam of Tolu is like Peru balsam, plus vanillin and a little volatile oil. On boiling with water, the latter turns acid.

Resinous compounds are much used in medicine as purgatives and as mucous-membrane stimulants. The common resins are also employed in making varnishes (copal chiefly), lacquers, and sealing wax. Japan is a sort of varnish made with shellac, linseed oil, turpentine and metallic oxids. Common rosin saponifies fat, and is used in making cheap soaps and in plasters, cerates and ointments. The rosin oil, obtained by destructive distillation, is used with lamp-black and sealing wax in preparing printers' ink. Shellac-covered capsules are utilized in intestinal disorders.

Identification of Rosin, or Colophony.—Boil a little of the powder with 4 times as much HNO_3; when cold, dilute with an equal amount of water and add NH_4HO, getting a blood-red coloration.

AROMATIC, OR BENZENE, SERIES.

The chief member of this series is benzene, phene, or benzol, C_6H_6, a colorless, very volatile liquid, with peculiar odor; sp. gr., 0.884; insoluble in H_2O, and derived by distillation from coal-tar—the light oil that floats on water, after removing phenol with NaHO, and basic compounds with H_2SO_4. It is very inflammable, and a good solvent for I, P, S, fats, oils, and resins. From it are derived most modern antiseptics, antipyretics, and dyes. Its molecule is a symmetric hexagon:—



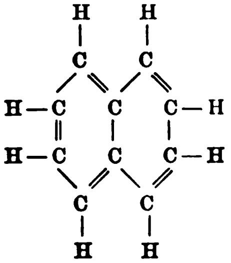
Experiment.—Make C_6H_6 by heating a mixture of CaO and dry benzoic acid, passing vapors into a test-tube set in ice.

Toluene, C_7H_8; xylene, C_8H_{10}; and cumene, C_9H_{12}, are also found in coal-tar. Cymene, $C_{10}H_{14}$, occurs in oil of thyme,

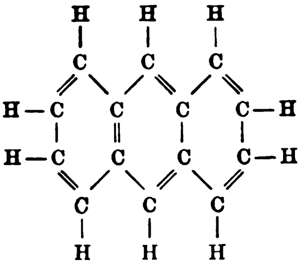
and is closely related to the terpenes, and can readily be obtained from them by dehydrogenation with Br or I.

Two or more benzene nuclei may be grouped together. Several uncondensed nuclei are present in the diphenyl, diphenyl-methane, triphenyl-methane, and indigo groups.

Naphthalene, $C_{10}H_8$, popularly known as "coal-tar camphor," or "tar balls," is constituted of two molecules of benzene condensed into one, as shown by this graphic formula:—



Anthracene (the basis of alizarin, or artificial madder, and turkey-red dye), and phenanthrene, $C_{14}H_{10}$, contain three condensed molecules of benzol:—



The purgative activity of rhubarb, aloes, senna and cascara is due to irritant anthracene (anthraquinone) compounds.

The terpenes may be regarded as cyclic compounds having one or more latent valences. When the cyclic hydrocarbon chain is composed of one kind of atoms (usually C), the molecule is homocyclic or isocyclic. When the chain includes atoms of different elements, it is heterocyclic.

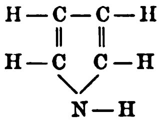
HYDROCARBON DERIVATIVES.

These are of two main classes: 1. The fatty, or aliphatic, **compounds of the first series,** arranged in open chains. 2. The **aromatic, or ring, compounds** of the fifth series. In both of **these groups the derivatives** are produced by substitution of **other elements or radicals** for one or more atoms of H in the **hydrocarbon. Hence they** are called substitution derivatives.

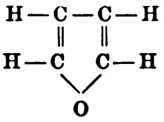
Addition derivatives are formed by direct union of unsaturated (second, third, and fourth series) hydrocarbons with elements or radicals.

When the C ring of benzene is broken by substitution of N for C, we have the pyridin group of compounds (quinolin by similar substitution in naphthalene; acridene from anthracene); by O for C in furfuran group; by S for C in thiophen compounds.

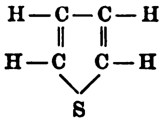
Pyrrol.



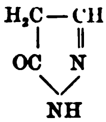
Furfuran.



Thiophen.



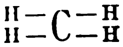
Pyrazolon.



The relations of hydrocarbon derivatives are shown most clearly by graphic formulas, substituting characteristic radicals for H in methane and in benzene. The presence of the various groups is shown by PCl_5 (HO group) and other reagents.

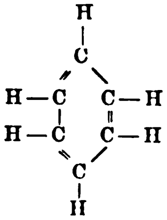
Hydrocarbons.

Methane = CH_4.

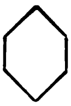


$$\begin{matrix} H- & & -H \\ & C & \\ H- & & -H \end{matrix}$$

Benzene = C_6H_6.



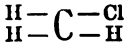
or simply



C and H being understood.

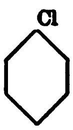
Halogen Derivatives.

Methyl chlorid = CH_3Cl.



$$\begin{matrix} H- & & -Cl \\ & C & \\ H- & & -H \end{matrix}$$

Phenyl chlorid = C_6H_5Cl.

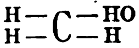


Sulphonic Compounds.

Replace one H with HSO_3.

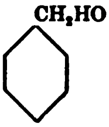
Alcohols, or Hydrates.

Methyl hydrate = CH_3HO.



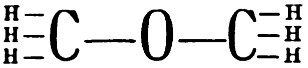
$$\begin{matrix} H- & & -HO \\ & C & \\ H- & & -H \end{matrix}$$

Benzyl alcohol = $C_6H_5CH_2HO$.



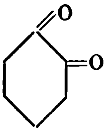
Ethers, or Oxids.

Methyl oxid = $(CH_3)_2O$.



$$\begin{matrix}H-\\H-\\H-\end{matrix}C-O-C\begin{matrix}-H\\-H\\-H\end{matrix}$$

Benzoquinone = $C_6H_4O_2$.

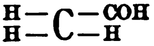


Thio-ethers and Alcohols.

Contain S instead of O.

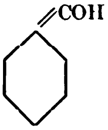
Aldehyds **(fundamental group = COH^{I}).**

Acetaldehyd = CH_3COH.



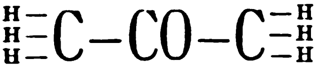
$$\begin{matrix}H-\\H-\end{matrix}C\begin{matrix}-COH\\-H\end{matrix}$$

Benzaldehyd = C_6H_5COH.



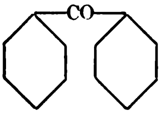
Ketones **(fundamental group = CO^{II}).**

Dimethyl ketone (acetone) = $(CH_3)_2CO$.



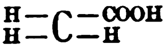
$$\begin{matrix}H-\\H-\\H-\end{matrix}C-CO-C\begin{matrix}-H\\-H\\-H\end{matrix}$$

Diphenyl ketone (benzophenone) = $(C_6H_5)_2CO$.



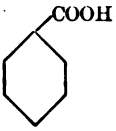
Organic Acids **(fundamental group = $COOH^{I}$).**

Acetic acid = CH_3COOH.



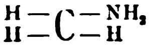
$$\begin{matrix}H-\\H-\end{matrix}C\begin{matrix}-COOH\\-H\end{matrix}$$

Benzoic acid = C_6H_5COOH.



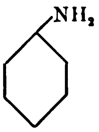
Ammonia Derivatives: Amins (H replaced by **basic radical**) **and** amids (**H** replaced by acid **radical**).

Methylamin = CH_3NH_2.



$$\begin{matrix}H-\\H-\end{matrix}C\begin{matrix}-NH_2\\-H\end{matrix}$$

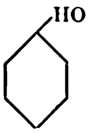
Phenylamin (anilin) = $C_6H_5NH_2$.



Carbohydrates.

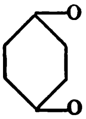
Sugar and starch groups of aldehyds and **ketones.**

Phenols (HO replaces H in C_6H_6).



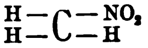
Phenyl hydrate (carbolic acid) = C_6H_5HO.

Quinones (substitute benzene compounds — 2 O for 2 H).
Benzoquinone = $C_6H_4O_2$.



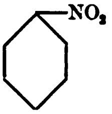
Nitrogen Derivatives (fundamental groups: — NO_2, nitro; — NO, nitroso; and = N — OH, isonitroso derivatives or oxims).

Nitromethane = CH_3NO_2 (an ester).



$$\begin{matrix} H - & & - NO_2 \\ & C & \\ H - & & - H \end{matrix}$$

Nitrobenzene = $C_6H_5NO_2$



Carbonyl Derivatives (fundamental group = CO^{II}).

Cyanogen Derivatives (fundamental group = CN^{I}).

Azo and Diazo Compounds. The diad group — N = N — is linked on both sides to a hydrocarbon radical in azo, to an acid radical and a hydrocarbon radical in diazo.

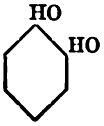
Hydrazins. Aromatic substitution derivatives of NH_2 — NH_2.

Alkaloids and Ptomains. Chiefly derivatives of pyridin and quinolin.

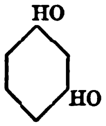
Proteins. *Phosphines* (alkyl substitution products of PH_3). *Arsines* (same of As_2O_3). *Stibines* (same of Sb_2O_3).

The arrangement of isomeric phenyl derivatives in ortho (1 and 2), meta (1 and 3), and para (1 and 4) compounds is shown below [$C_6H_4(HO)_2$], Dihydroxy-benzene:—

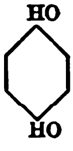
Pyrocatechin.



Resorcin.



Hydroquinone.



Where there are three atoms or radicals substituted for H in benzene, the arrangement 1-2-3 is termed consecutive or adjacent; 1-2-4, unsymmetric; and 1-3-5, symmetric. Alpha compounds have the arrangement 1-4; beta, 2-3-5-6.

ALKYL, OR ETHEREAL SALTS.

Cl and Br can act directly on hydrocarbons, replacing H; I acts indirectly. The halogen derivatives comprise many general and local anesthetics. They have a sweet, ethereal odor and taste, and are more or less volatile and soluble in alcohol and ether, and generally insoluble in H_2O. They are liable to decompose in the light, setting free the halogen. In other respects they are stable.

Methyl chlorid, CH_3Cl, is prepared by heating CH_3HO with a mixture of NaCl and H_2SO_4. CH_4 and Cl unite in sunlight to form CH_3Cl. It is a colorless, combustible gas, liquefying at 22° or with 5 atmospheres' pressure. In the liquid form it is used as a refrigerant local anesthetic.

Ethyl chlorid, C_2H_5Cl, is a colorless liquid used as a local and general anesthetic. Its solution in alcohol is known as chloric ether.

Ethyl bromid is a heavy, colorless liquid, boiling at 39°. It has been used as a general anesthetic. Ethylene bromid, $C_2H_4Br_2$, is quite poisonous. It is decomposed quantitatively when heated with Zn and a little water, forming $ZnBr_2$ and C_2H_4 (burns with smoky flame).

By far the most important halogen derivative is *chloroform* (trichlormethane), $CHCl_3$. It is prepared by the action of chlorinated lime on ordinary alcohol or acetone or (the purest) from chloral.

Experiment.—Make $CHCl_3$ by mixing in a test-tube retort chlorinated lime with ¼ as much acetone and 3 times as much H_2O, and then distilling on the water-bath into a beaker. The chloroform collects as a heavy, oily liquid at the bottom of the beaker, and is separated and washed with H_2SO_4, treated with Na_2CO_3, and redistilled over CaO.

$$2C_3H_6O + 3CaO_2Cl_2 = 2CHCl_3 + 2Ca(HO)_2 + Ca(C_2H_3O_2)_2$$

Chloroform is a limpid, caustic liquid; sp. gr., 1.49; b.p., 60°. It tends to decompose in light or heat, setting free Cl, formic acid and HCl and the poisonous compound carbonyl chlorid, $COCl_2$. Pure $CHCl_3$ evaporates without residue, is neutral to litmus, and gives no ppt. with $AgNO_3$ nor darkens with KHO or H_2SO_4. One-half to 1 per cent. alcohol is allowable, and renders $CHCl_3$ more stable.

Experiment.—Test some of the prepared $CHCl_3$ by heating with a drop each of alcoholic solution KHO and anilin. The offensive odor of phenyl-carbylamin. or isobenzo-nitril, C_6H_5NC, is produced. The test shows 1 part in 5000.

Test another portion by boiling with a few drops of KHO and a fragment of resorcin, getting an intense red coloration of rosolic acid, showing a brilliant green fluorescence on diluting with H_2O. Chloral shows both of these reactions, but has a different odor. Paper dipped in $CHCl_3$ burns with a green mantle, and HCl is given off.

On warming chloroform with α- or β- naphthol in strong KHO solution, a blue color appears, turning green and finally brown.

$CHCl_3$ is a good solvent for I, P, resins, camphor, alkaloids, caoutchouc, and fats, but its chief use is as an anesthetic, for which purpose it should always be administered with plenty of air or O. Four per cent. is the limit of safety. Owing to its high b.p., it is easy to supersaturate the blood and cause death from inhalation.

Chloroform enters into loose combination with the lecithin of the red cells and the brain, causing slight coagulation of the protoplasm of the ganglion cells.

It is eliminated chiefly as chlorids by the kidneys. In contact with a naked flame $CHCl_3$ vapor evolves free Cl and HCl, which excite laryngeal and pulmonary congestion and inflammation. The spirit is 6 per cent. in strength by volume. The water is a weak, but saturated, solution prepared by shaking. CCl_4 is used as a cleansing agent and solvent under the trade names carbona, pyranzine or eradeline.

Iodoform (triiodo-methane), CHI_3, is prepared by the action of I on alcohol or acetone in the presence of alkalies. It appears in microscopic, light-yellow hexagonal crystals with strong saffrony odor. It sublimes readily, and melts at 119°. It is soluble in oils, alcohol, ether, and $CHCl_3$. Its antiseptic effect depends on the liberation of I (of which it contains 96 per cent.) in presence of moisture.

Experiment.—Make CHI_3 by dropping a few crystals of I into quite dilute alcohol and then adding KHO drop by drop, warming gently, till the red color just disappears. When sediment has settled, examine crystals under microscope. On a large scale K_2CO_3 with heat is employed instead of KHO.

$$C_2H_5HO + 4I_2 + 6KHO = CHI_3 + KCHO_2 + 5KI + 5H_2O$$

Bromoform, $CHBr_3$, is a colorless liquid (sp. gr., 2.8), prepared similarly to CHI_3. It resembles $CHCl_3$ and is used as a sedative, particularly in coughs. There are 300 drops (60 minims) in a fluidram of $CHBr_3$.

ALCOHOLS.

These are hydrates of hydrocarbon radicals. Organic hydroxids are distinguished by the suffix *ol;* as methanol. According to the number of HO groups, they are termed monatomic (monohydric), diatomic (glycols), triatomic (glycerols), etc., up to nonatomic. They are also classified as primary, secondary (carbinols), and tertiary, each being characterized by the fundamental group $(CH_2.OH)^{I}$, $(CH.OH)^{II}$, and $(C.OH)^{III}$, respectively. The lower members are liquids, the higher solids. Alcohols are readily oxidized: primary to aldehyds and monobasic acids, secondary to ketones, and tertiary to simple compounds:—

$$CH_2.OH + O = H_2O + COH \qquad COH + O = COOH$$
$$CH.OH + O = H_2O + CO$$

Treated with an acid, alcohols form ethereal salts and water. Treated with a base, they yield a salt of the base and free H:—

$$C_2H_5HO + KOH = KC_2H_3O_2 + 2H_2$$

Alcohols are neutral, but it is possible to replace the H of HO with a metal, forming alcoholates, such as C_2H_5ONa. Primary monatomic alcohols are the most important, and are derived from the saturated hydrocarbons of the first series.

Methyl alcohol (carbinol, wood-spirit), CH_3HO, is present in the oil of wintergreen, but is prepared chiefly by the destructive distillation of wood and as a by-product in beet-sugar manufacture. Its sp. gr., is 0.8; b.p., 66°. It mixes with H_2O in all proportions. Its vapor is explosive. CH_3HO is a solvent for fats, oils, camphor, and resins, and is used in the manufacture of varnishes and organic dyes, for heating purposes, and in the preparation of methylated spirit (90 per cent. raw spirit, 10 per cent. wood spirit—denaturized grain alcohol for industrial purposes, to avoid tax—contains also 0.5 per cent. benzin). The disagreeable odor and taste of commercial CH_3HO are due to tarry impurities, aldehyd, acetone, etc.

Test for Methyl Hydrate.—Warm a few c.c. of distillate with $K_2Cr_2O_7$ and H_2SO_4, neutralize with $CaCO_3$, add $Pb(C_2H_3O_2)_2$, filter and test filtrate for formic acid by warming with ammoniacal $AgNO_3$, getting a silver mirror.

Test for Wood Alcohol in Dilute Liquids.—Heat a spiral Cu wire to bright-red heat, and plunge into a small quantity of the liquid at least six times. Add one drop of 0.5 per cent. aqueous solution of resorcin, and pour carefully onto conc. H_2SO_4. A rose-red zone at the junction of the two liquids (formaldehyd), with scanty white or pinkish coagulum above this zone, rising in purplish flecks, shows a positive reaction.

The official alcohol is ethyl hydrate, C_2H_5HO (methyl carbinol, $CH_3.CH_2HO$). It occurs in diabetic urine, and is formed by alcoholic fermentation of maltose ("mash") or glucoses: $C_6H_{12}O_6 = 2C_2H_5HO + 2CO_2$. There is also formed about 3 per cent. of glycerin, 0.6 per cent. succinic acid and 0.4 per cent. of higher alcohols. The fermented product is purified by distillation over dehydrating agents, such as $CaCl_2$, CaO, $CuSO_4$, charcoal, or wood-ashes. Absolute alcohol contains less than 0.5 per cent. H_2O. It boils at 78.5° and freezes at — 130°. Its sp. gr. is 0.7937. Absolute alcohol is a transparent mobile liquid, very hygroscopic; hence it dehydrates tissues and is used to harden histologic and pathologic specimens for the microtome. For the same reason it is antiseptic, preventing decay and coagulating albumin. Alcohol is a good solvent for resins, alkaloids, and volatile oils. It burns with a non-luminous flame. Ordinary alcohol (sp. gr., 0.82) is 94.9-per-cent. strength by volume; the dilute (sp. gr., 0.928), 48.9 by volume, 41 per cent. by weight. Alcohol and dilute alcohol are used as menstrua for both extracts and fluidextracts.

Experiment.—Show that ordinary alcohol contains H_2O by adding to it some white anhydrous $CuSO_4$. Explain color-change.

Test for C_2H_5HO.—Mix with dry $NaHO$ and a few drops of CS_2. Allow excess of latter to evaporate, and add a drop of neutral, aqueous $(NH_4)_2MoO_4$; then acidulate with H_2SO_4. A wine-red color results. Test is rendered negative by presence of sugar.

Alcohol is a stimulant in small doses, and depressant and narcotic in large. In the system it is burned partly (1½ or 2 oz. daily) into CO_2 and H_2O, the remainder passing off unchanged. In spite of this fuel action, it is not strictly a food. It causes accumulation of fat through decrease of activity and is not stored in the body. It causes the dissolution of chromophilic nerve-cells. Alcohols are not dissociated in the body, as are the mineral hydroxids. Alcohol is a local irritant and, properly diluted, may quicken the healing of sluggish sores as well as prevent the formation of bed-sores. Tincture of arnica and the distilled extract of witchhazel owe what good effects they may exert almost entirely to the contained alcohol.

Experiment.—Make C_2H_5HO by adding a little brewers' yeast to a solution of 5 gm. commercial glucose in 200 c.c. H_2O. Let the flask stand in a warm place for a day, then distill and collect a few c.c. of the liquid. Test distillate by adding half as much H_2SO_4 and an equal volume of $K_2Cr_2O_7$ solution. Aldehyd is formed and is recognized by its peculiar odor; the liquid turns green by formation of $Cr_2(SO_4)_3$. The iodoform test, already described, may also be employed.

Alcoholic liquors are classified as malt-products, wines, and spirits. Malt-liquors include beer, ale, stout, and porter. These are formed by diastatic and alcoholic fermentation of malted barley. The ferment diastase in the grain on warming develops dextrin and maltose, as the grain sprouts; further growth is stopped (in 2 or 3 weeks) by heating the grain on the floor of the malt-kiln, the degree of heat used corresponding with the depth of color required; the malt is next bruised in hot water in the "mash-tun"; the liquid is now boiled and the bitter principle added; then yeast is added to the cooled "wort" to set up alcoholic fermentation. These malt-liquors contain 2 to 8 per cent. of alcohol (beer weakest, ale strongest); also CO_2 and malt-sugar. Hops are added to beer as a preservative, and glycerin to cause foam. Hard cider contains about 5 per cent. of alcohol.

Mead, rootbeer and spruce beer contain up to 1 per cent. alcohol. The dark color of porter is due to caramel or assamar. Beer and stout contain 2 to 5 per cent. of dextrin. Sake is a Japanese drink made by fermenting rice.

Experiment.—To find the percentage of alcohol in beer, or other liquor, take sp. gr. with picnometer, place 100 c.c. in an evaporating-dish and drive off rather more than half the amount; make up to original volume with water, and take sp. gr. again at the same temperature as before. The original sp. gr. divided by this latter equals the sp. gr. of alcohol expelled, and from this, by reference to tables, the percentage of alcohol is found.

Wines are prepared from grapes fermented by the action of a living ferment always present on grape-stalks and in the air. If only the must or grape-juice is used a white wine (official, 10 to 14 per cent.) results; if the marc, or skins and seeds, is included, a red wine (same strength as white). The "ripening" of wine in casks takes from two to eight years.

Champagne and other effervescing wines are bottled before fermentation is quite complete, with addition of alcohol and cane-sugar. The alcoholic strength of wines varies from 5 per cent. for light Rhine to 18-25 per cent. in sherry and port. These strong wines are fortified by addition of spirit (prevents souring).

Wines ordinarily contain no more than 16 per cent. alcohol, as this strength inhibits yeast fermentation. The character of wines depends largely on the amount of albumin present, serving as food for the yeasts. If the yeast soon ceases action, we have a sweet wine (4 per cent. sugar); if it converts nearly or all the sugar, a dry or acid wine. Dry champagne (9-12 per cent. alcohol) has 8 per cent. sugar added; sweet champagne, 16 per cent. The body of wines depends on alcohol and extractives (gums and pectins). Bordeaux and Burgundy have much body. The bouquet of wines is due to a combination of ethers, chiefly enanthic (heptyl) ether. Rough wines contain little alcohol, but considerable tannin.

Fining consists in the addition of egg albumen, isinglass or other gelatinous matter, to drag down suspended particles and so clarify the liquid. Gallizing wines consists in diluting the must to reduce acidity to a given standard, and adding sugar to insure proper alcoholic strength. Chaptalizing consists in neutralizing the acidity of must with marble dust and cane-sugar or glucose; it increases the yield of alcohol. Plastering wines decomposes $KHC_4H_4O_6$ in the must and throws down phosphates:—

$$2KHC_4H_4O_6 + CaSO_4 = K_2SO_4 + CaC_4H_4O_6 + H_2C_4H_4O_6$$

The acids (tartaric, malic, tannic) in wine rarely exceed 0.5 per cent. The tartrate of Ca falls down and carries with it albumen and suspended impurities. The tartaric acid makes the wine redder and increases free acidity, facilitating the production of ethers later on.

Spirits are liquors distilled from grains, potatoes, beets, rice, etc., that have been mixed with malt and then yeast. Brandy, or cognac, is produced by distillation of wines; rum from fermented cane-molasses and other waste products of sugar manufacture; whisky from corn, rye, barley, and potatoes; arrack and shochu from fermented rice; pulque, or mescal, from the maguey. Gin is common grain-spirit distilled with juniper berries. Bay-rum is prepared by distilling rum with leaves of Myrcia acris and other plants.

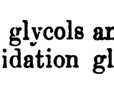
Spirits derive some color from the containing casks, and are sometimes colored with caramel. The characteristic taste of good brandy is due to a volatile oil. Gin may be flavored with almond, angelica, calamus, cardamom, cassia, cinnamon, coriander, orange peel, orris root or sweet fennel. Irish whisky is made from a mixture of malt and unmalted grain. The characteristic smoky taste of Scotch whisky depends on drying the malt over a peat fire. Whisky has 50 to 58 per cent. alcohol by volume; brandy, 46 to 55 per cent.; gin, usually 15 to 20 per cent. Distilled, or "raw, spirit" (about 14 per cent.) is concentrated and rectified by charcoal filtration and redistillation to 84 per cent., by weight ("spirit of wine"). The most concentrated alcohol by simple distillation is 91 per cent. by weight, 94 per cent. by volume. Alcoholimetry, the testing of strength of alcohols, is based upon sp. gr. tables.

Liqueurs, or cordials, are manufactured of alcohol (40 per cent.), sugar (25 per cent.), essential oils (wormwood and star anise in absinthe) and vegetable or coal-tar coloring matters. Vermuth is a fortified white wine infusion of herbs and other vegetables, and contains oil of wormwood. Sparkling wines are flavored with liqueurs. Old sherry and cognac contain a very large proportion of volatile ethers; hence stimulating.

The oily liquid, amyl alcohol [$C_5H_{11}HO$], is the chief ingredient of fusel oil, a mixture of higher homologues present largely in raw spirit and separated by fractional distillation, C_2H_5HO distilling over at a lower temperature. The bad taste and intoxicating effects of poor quality ardent spirits are due, in great measure, to fusel oil, on which also depends the odor of spirits in the breath. Alcohol containing fusel oil darkens on shaking with H_2SO_4. Pyronic aldehyd, or furfurol, is a convulsant poison present in vermuth and bitters and fresh spirit.

The tertiary isomer of amyl alcohol, amylene hydrate [dimethyl-ethyl-carbinol, $(CH_3)_2.COH.C_2H_5$] is a colorless, oily liquid, soluble in water and in alcohol, and used as an hypnotic. The higher monatomic alcohols are fatty and waxy solids. Cholesteric alcohol, $C_{27}H_{45}HO$, is the only free alcohol normally present in the human body. It is the principal ingredient of gall-stones. Oil of rose is a mixture of two alcohols, $C_{10}H_{17}HO$ and $C_{10}H_{19}HO$.

The primary diatomic alcohols, or glycols, are derived from olefins, and are of no practical interest. They are sweet, syrupy liquids. The simplest one is glycol:—



$$\begin{array}{l} CH_2—OH \\ \mid \\ CH_2—OH \end{array}$$

A sweet taste is common to glycols and other alcohols containing many OH groups. On oxidation glycols yield lactic or oxalic acid.

The primary triatomic alcohols, or glycerins, are of great interest and importance. Ordinary glycerin, or propyl hydrate [$C_3H_5(HO)_3$], occurs very abundantly in Nature, making up, in conjunction with fatty acids, the bulk of vegetable and animal fats and oils, from which it is liberated by treating with alkalies. It is a by-product in alcoholic fermentation and in the manufacture of soap and stearic acid. It is also produced on a large scale by passing steam at 120-150 pounds pressure through fats in copper digesters.

The sp. gr. of glycerin is 1.25; it freezes at —40° and boils at 290°. It is very hygroscopic, absorbing twice its volume of H_2O, and thus depleting congested tissues. Glycerin is insoluble except in alcohol and water. It is an excellent solvent for I, Br, starch, carbolic acid, alum, borax, and tannin, such solutions being often termed glycerites. The purest glycerin contains 6 to 8 per cent. of H_2O.

In some respects it is preferable to syrups as a sweetening agent, since it does not ferment. It is also an excellent excipient for fluid extracts. Plasmas are non-fatty ointment substitutes or paints consisting principally of glycerin and water thickened into a gelatinous mass with starch, gelatin, isinglass, and other agents. Most medicated gauzes and cottons contain a small quantity of glycerin or oil and resin to keep them soft and promote the action of the medicinal agents. The "soft gelatin" capsules for liquids contain glycerin. When glycerin is used as a protective (chapped hands, etc.), it should be diluted (4 parts water) to the sp. gr. of blood-serum.

Boroglycerin, $C_3H_5BO_3$, is made by heating H_3BO_3 with one and one-half times as much glycerin. It is used as an antiseptic.

Experiment.—Test for glycerin with borax bead. The green flame is due to free boric acid:—

$$C_3H_5(HO)_3 + Na_2B_4O_7 = H_3BO_3 + 2NaBO_2 + C_3H_5BO_3$$

On heating glycerin with $KHSO_4$ crystals, the characteristic irritating odor of acrolein (C_3H_4O) is evolved. This test also applies to neutral fats, but not to fatty acids or soaps.

Glycerophosphoric acid is a yellow, syrupy liquid prepared by mixing 1 part of H_3PO_4 with 1½ parts of glycerin, and gradually heating to 190°. Both the acid and its salts are used as nervine remedies and to aid nutrition.

The hexatomic alcohols—mannite, dulcite, and sorbite—have the formula $C_6H_{12}O_6$. The first is derived from manna-ash, the second from Madagascar manna, and the third from the berries of the mountain-ash. They resemble sugar in taste, but do not ferment or reduce metallic solutions. Aromatic alcohols are really methane derivatives in which the H of the hydrocarbon residue has been replaced by C_6H_5. Both fatty and aromatic alcohols can be produced by reducing the corresponding aldehyds or by heating halogen derivatives with H_2O or weak alkalies.

ETHERS.

Simple ethers are oxids of hydrocarbon radicals; if the radicals are unlike, the ether is termed mixed. A compound ether, or ester, is produced by replacing H of an acid by a hydrocarbon radical; in other words, a salt of an alkyl radical. Ethers are generally formed by the dehydrating action on alcohols of H_2SO_4 or by combination of other acids with alcohols. The compound ethers have usually a pleasant and refreshing odor. They give the bouquet or flavor to alcoholic liquors, where they are generated by age, and they are the chief constituents of fats and fixed oils, beeswax (melyssyl palmitate), and spermaceti (cetyl palmitate). Beeswax (cera flava) is bleached (cera alba) by exposure to light and air or by the use of H_2O_2. It is used in candles. All ethers are neutral. The lower members are volatile liquids; the higher, non-volatile solids. Esters are decomposed by alkalies, which combine with the acid radical, setting free the alcohol. Artificial fruit-flavors consist chiefly of butyrates, acetates, and salicylates of ethyl, methyl, and amyl in glycerin and water. The odor of senega is due to methyl valerate.

Ordinary ether is ethyl oxid [$(C_2H_5)_2O$], sometimes called sulphuric ether because H_2SO_4 is used in its manufacture.

Experiment.—Make ether by mixing in a flask 10 c.c. of alcohol, 5 c.c. of H_2SO_4, and, after cooling, distilling over the ether at about 140° into a stoppered bottle. Take great care not to bring the vapors into contact with the flame.

$$C_2H_5HO + H_2SO_4 = C_2H_5HSO_4 \text{ (sulphovinic acid) } + H_2O$$
$$C_2H_5HSO_4 + C_2H_5HO = (C_2H_5)_2O + H_2SO_4$$

On a large scale the process is made continuous by allowing alcohol to flow into the flask at the same rate as distillation. The product is purified by mixing with oxid and chlorid of Ca, pouring off the clear liquid after settling, and distilling.

The official ether contains 96 per cent. of $(C_2H_5)_2O$ and 4 per cent. of C_2H_5HO. It is a colorless, mobile, and very volatile liquid, with characteristic odor, burning taste, and neutral reaction; sp. gr., 0.726; b.p., 37°. It is soluble in 10 volumes of H_2O and in alcohol, chloroform, petroleum liquids, and fixed and volatile oils, and is itself a good solvent for fats, fixed oils, and gun-cotton (collodion). It burns readily with a luminous flame, and gives off a combustible vapor.

Experiment.—Show inflammability of ether by applying a flame to a dram of it in a dish. Note the initial explosion and rapid combustion.

Ether vapor reduces $K_2Cr_2O_7$ to green chromium sulphate —best done with filter-paper.

Ether is used by inhalation as a general anesthetic, being less depressing, but more irritating, than $CHCl_3$. Ether and chloroform are absorbed and excreted almost wholly by the lungs, according to the ordinary physic laws of absorption of gases by fluids. The greater the concentration of vapor in the lungs, the more is absorbed into the blood, and overconcentration at any time, rather than the total amount inhaled, may give rise to dangerous symptoms.

Test for Purity of Ether.—Water is detected by turbidity when shaken with an equal volume of CS_2; alcohol by shaking with anilin-violet, which colors ether containing alcohol.

The spirit and compound spirit of ether consist of about 1 part of ether and 2 parts of alcohol; the latter spirit contains 2½ per cent. of ethereal oil, which is a mixture of equal volumes of ethyl sulphate (heavy oil of wine) and ether.

Acetic ether, $C_2H_5.C_2H_3O_2$, is a colorless, mobile liquid of a pleasant, acetous, and fruity odor and generally soluble.

Experiment.—Prepare ethyl acetate by warming alcohol with half as much again each of H_2SO_4 and $NaC_2H_3O_2$. Note odor and write equation.

Methyl salicylate, $CH_3.C_7H_5O_3$, is identic with oil of betula and the essential constituent of oil of wintergreen. It is present in senega root. It is prepared by distilling a mixture of methyl alcohol, salicylic acid, and H_2SO_4. Anisol, $C_6H_5.CH_3O$, is also found in oleum gaultheriæ.

Nitrous ether, $C_2H_5.NO_2$, is made by distilling a mixture of C_2H_5HO, H_2SO_4, and $NaNO_2$. Sweet spirit of niter contains 4 parts of this ether with 96 of alcohol.

Nitroglycerin (pyroglycerin) $[C_3H_5(NO_3)_3]$ is prepared from glycerin and sulphuric and nitric acids. It is a yellow liquid, slightly soluble in alcohol; the 1-per-cent. solution is known as spirit of glonoin. Nitroglycerin is very explosive when struck or heated to 257°. The products of such an explosion are shown by the following equation:—

$$4C_3H_5(NO_3)_3 = 12CO_2 + 10H_2O + 6N_2 + O_2$$

These four gases occupy a space about 18,000 times as great as that of the original explosive. When used for this purpose it is generally mixed with some dry, inert powder (charcoal, silica, and sawdust) and sold as dynamite, or giant powder (75 ng., $25SiO_2$).

Amyl nitrite, $C_5H_{11}NO_2$, is prepared in the same way as ethyl nitrite, except that amyl alcohol is used in place of ethyl alcohol. It is a pale-yellow liquid, with the strong, peculiar odor of amyl compounds, and is used by inhalation as a quick stimulant.

Amyl acetate, $C_5H_{11}.C_2H_3O_2$ ("essence of pear"), is used by confectioners as a flavoring agent.

Salol, or phenyl salicylate, $C_6H_5.C_7H_5O_3$, is prepared by heating salicylic acid in an atmosphere of CO_2, whereby it loses H_2O and CO_2. It occurs in white, faintly aromatic crystals, generally soluble except in water. Taken internally, it is broken up in the duodenum into phenol and salicylate. The same change takes place when salol is combined with caustic hydroxids.

Experiment.—Dissolve a little salol by warming with liquor potassæ. Add excess of HCl, and note odor of phenol and ppt. of salicylic acid in silky needles.

The depilatory, sodium ethylate, NaC_2H_5O, is decomposed by water into alcohol and caustic soda.

ALDEHYDS.

These compounds are formed, as the name suggests, by dehydrogenation of alcohols, usually by oxidation; for example, $C_2H_5HO - H_2 = CH_3COH$ (ethyl aldehyd). The group COH is characteristic of all aldehyds. They are intermediate between alcohols and acids, and are strong reducing agents.

Schiff's Reaction.—A pink solution of fuchsin almost decolorized with H_2SO_3, turns pink or violet after adding a few drops of any aldehyd solution, or on exposure on filter-paper to gas. This test is not distinctive.

Formaldehyd (methyl aldehyd), HCOH, is obtained by passing air and vapors of CH_3HO over a heated spiral of Pt or Cu:—

$$CH_3HO + O = H.COH + H_2O$$

It is a colorless gas with a pungent odor. A 40-per-cent. solution in H_2O is known as formalin, and is largely used for general antisepsis in ¼- to 2-per-cent. solution. Its affinity for H_2O causes it to act as an escharotic in strong solutions, and accounts for its value in sterilizing catgut and hardening anatomic specimens. It is the basis of many embalming fluids.

Paraformaldehyd, $(HCOH)_3$, is the triple polymer of formaldehyd, produced by slow evaporation of the latter in CH_3HO. It is a crystalline solid, insoluble in H_2O. On heating it breaks up into 3 molecules of HCOH, and is very convenient for sterilizing instruments in this way.

Acetic, or ethyl, aldehyd, $CH_3.COH$, is ordinary aldehyd, obtained from C_2H_5HO by oxidation with $K_2Cr_2O_7$ in presence of H_2SO_4:—

$$4H_2SO_4 + K_2Cr_2O_7 + C_2H_5HO = CH_3.COH + Cr_2(SO_4)_3 + K_2SO_4 + 5H_2O + O_2$$

Experiment.—Place in a large flask 2 parts of $K_2Cr_2O_7$ and 6 parts of H_2O, and then pour in carefully through stopcock funnel a mixture of equal parts of C_2H_5HO and H_2SO_4, and warm gently. Note the peculiar fragrance of aldehyd evolved. Now adapt a cork and a long, bent glass tube and distill slowly into another test-tube. Boil a portion of distillate with KHO and get a brown-yellow, resinous mass. Let the other portion stand for a day or two, when it will be found acid, and, on neutralizing with Na_2CO_3, boiling, and adding H_2SO_4, the characteristic odor of acetic acid is noted:—

$$CH_3.COH + O = CH_3.COOH$$

Paraldehyd is the triple polymer of aldehyd, obtained by adding a few drops of conc. H_2SO_4 to aldehyd and crystallizing at 0°. It is solid, soluble in 8.5 H_2O, and used as an hypnotic in elixirs. Metaldehyd is stereoisomeric, and liquefies at 10.5°.

Trichloraldehyd, or chloral, $CCl_3.COH$, is a simple substitution derivative of aldehyd, prepared by saturating cold alcohol with Cl (forming chloral alcoholate), then warming to the b.p., and, after cooling and shaking with H_2SO_4, distilling the lower liquid layer at 94° to 99°. Chloral is a colorless, oily liquid with a sharp odor and acrid taste. Its hydrate, $CCl_3.$-$COH.H_2O$ is a valuable hypnotic, obtained by the simple addition of H_2O. Chloral hydrate appears in white crystals, soluble in all the common solvents. It liquefies when mixed with stearoptens or phenol, and is incompatible with alkalies. Butyl chloral hydrate is an analogous compound derived from C_4H_9OH.

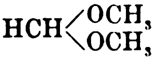
Chloral does not break up into chloroform in the blood, but is excreted in the urine in combination with glycuronic acid (urochloralic acid). Its continued use leads to imperfect oxidation (fatty degeneration) and augmented destruction of body proteids.

Experiment.—Heat chloral hydrate with KHO and note odor of chloroform.

Benzaldehyd, $C_6H_5.COH$, is the oil of bitter almond, formed by decomposition of the glucosid amygdalin through the action of the ferment emulsin in presence of H_2O. It is a colorless, oily liquid with bitter, burning taste and characteristic aromatic odor; sp. gr., 1.045. The crude oil contains HCN. Aqua amyg. amaræ has 1 part of the oil in 999 of water. Cinnamic aldehyd, C_9H_8O, is obtained from oil of cinnamon, or prepared synthetically. It is a colorless liquid with a characteristic odor and burning, aromatic taste; sp. gr., 1.047.

ACETALS.

These compounds are formed by union of alcohols and aldehyds, with elimination of water. Methylal (formal)



$$HCH\begin{cases}OCH_3\\OCH_3\end{cases}$$

is a mobile, colorless liquid of aromatic odor, freely miscible with solvents, and used in medicine as an hypnotic. Acetal (diethyl-acetal), $C_6H_{14}O_2$, is similar in physic properties.

KETONES.

As already stated, these compounds are formed by oxidation of secondary alcohols, and are characterized by the group CO^{II}. Like the aldehyds, they are neutral and tend to polymerize, but do not reduce ammoniacal silver solutions as do the former. On oxidation they split into two acids.

The only important ketone is acetone, or dimethyl-ketone, $(CH_3)_2CO$. It is often present in distinct quantity in diabetic urine, and is a product of the distillation of carbohydrates. It is prepared technically by dry distillation of $Ca(C_2H_3O_2)_2$, the carbonate remaining. It is a liquid of pleasant, minty odor and sharp taste, soluble in water, alcohol, and ether. It gives the iodoform test, the same as alcohol. Its principal uses are as a solvent for resins in varnishes and as a source of $CHCl_3$, CHI_3, sulphonal, and trional. **It is used as the menstruum in the preparation of all the official oleoresins, except cubeb, in which alcohol is employed.** Acetone combines with two molecules of C_2H_5HO to form ketol, $(CH_3)_2.C.(C_2H_5O)_2$, and H_2O. Oil of rue is chiefly methyl-nonyl ketone, $C_9H_{19}.CH_3.CO$.

ORGANIC ACIDS.

Organic acids are characterized by the fundamental group carboxyl, $COOH^I$, replacing H in hydrocarbons. They are monobasic, dibasic, or tribasic according to the number of carboxyl groups. By replacing H of COOH with metals various salts are formed. The term acid radical signifies the residue of the acid left after subtracting HO. These differ from alkyl or alcohol radicals in containing O. Acids may be considered hydroxids of acid radicals, and their anhydrids oxids of acid radicals. The organic acids include both solids and liquids, generally colorless. The variously colored scale compounds are generally solutions of fresh metallic hydrates (Fe particularly) in organic acids or acid salts, said solutions being dried on glass plates.

The fatty-acid series of saturated monobasic acids have the general empiric formula $C_nH_{2n}O_2$. The higher members occur abundantly with glycerin in natural oils and fats and with monatomic alcohols in waxes. Vegetable acids are widely distributed throughout nature, being partly free and partly combined with metals and alkaloids. Oxalic acid is most abundant, giving the sour taste to many plants.

Organic acids are absorbed mostly as salts of the alkaline metals, and are oxidized to carbonates in the cells, rendering the blood more alkaline and the urine less acid. Vegetable acids stimulate the alimentary secretions, causing flatulence and diarrhea.

Formic acid, H.COOH, occurs in ants *(formica rufa)*, bristles of stinging nettles, and fir-cones, as well as in perspiration, urine, and muscle-plasma. In the venom of bees and hornets it is united to $C_{11}H_{24}$. It may be obtained by heating oxalic acid in presence of glycerin, or by oxidation of methyl alcohol:—

$$CH_3HO + O_2 = H.COOH + H_2O$$

Formic acid is a colorless liquid with sharp odor and irritating action on skin.

Experiment.—Warm H.COOH gently with a few drops of H_2SO_4. The latter acid removes H_2O, and CO is evolved, as proved by burning; no ppt. with lime water.

Acetic acid, $CH_3.COOH$, is found in various plant-juices, partly free and partly combined with K and Ca. It is formed during the decay of many organic substances, and is commonly manufactured by "acetic fermentation" or slow oxidation of weak alcoholic liquors (trickling over wood-shavings in perforated casks) or by the dry distillation of wood. The fermented product is ordinary vinegar, which contains 4 to 10 per cent. of acetic acid. In the "quick vinegar" process the malt wort, grape juice, hard cider, etc., is warmed to about 80° F., and has added to it about ⅕ its volume of vinegar. A few percolations complete acetification in from 12 to 24 hours, yielding vinegar of a strength up to 15 per cent. The wood-product, known as pyroligneous acid, is neutralized with milk of lime, the tarry impurities are roasted away, and then, after treating with HCl, the liquid is distilled. Acetic acid is strongly acid, with a distinct vinegar odor. It is a solvent for resins and camphor, and

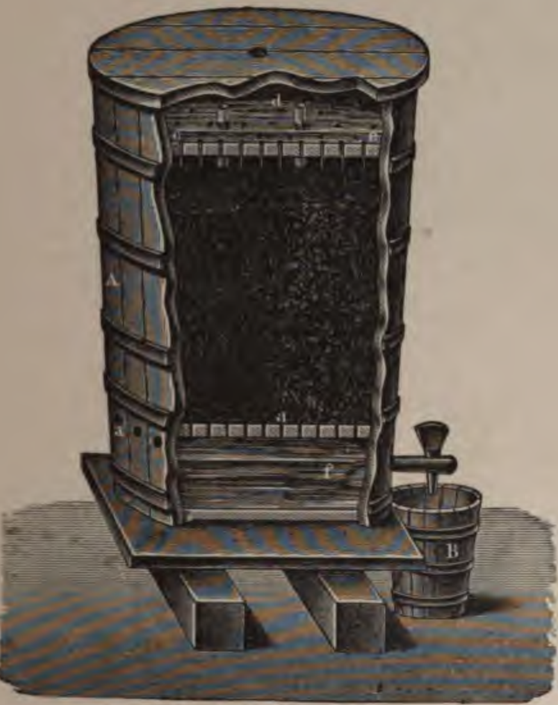


Fig. 34.—Quick Vinegar Process.

is used largely in manufacturing organic dyes and (10 per cent.) in the extraction of drugs (colchicum, conium, nux vomica, sanguinaria). The official fluidextracts of squill, lobelia and sanguinaria are prepared by the use of acetic acid in the menstruum.

The glacial acid, so called because it crystallizes below 17°, is over 99 per cent. absolute, and is used as a caustic. The official acid contains 36 parts by weight of the acid and 64 of H_2O; the dilute is of 6-per-cent. strength. It is a curious fact that the highest sp. gr. (1.074) of acetic acid is that of 78-per-cent. strength (acid combined with 1 molecule H_2O). Dilute acetic acid neutralized with $(NH_4)_2CO_3$ forms solution of ammonium acetate; a valuable diaphoretic. Acetates are neutral and soluble in water, except some basic salts.

Experiment.—Heat some $NaC_2H_3O_2$ with a drop or two of H_2SO_4 and note vinegar odor.

Carefully neutralize $HC_2H_3O_2$ and add solution of $FeCl_3$. A deepred color results, and on boiling a reddish-brown ppt.

Trichloracetic acid, $CCl_3.COOH$, is formed by oxidation of chloral with HNO_3. It is a crystalline caustic and ppts. albumin.

Propionic acid, $C_2H_5.COOH$, is so called because it is the first acid (protos, pion) which can be separated in an oily layer by adding $CaCl_2$, etc. It is a liquid with a peculiar odor, and is present in sweat and urine.

Butyric acid, $C_3H_7.COOH$, is the characteristic acid of butter, where it exists free when rancid, as also in feces and sweat. It is a liquid, differing from higher, common, fat acids in being miscible with H_2O.

Of the four valeric, or valerianic, acids, $C_4H_9.COOH$, the *iso* is the most important. It has the odor of valerian, and is found in this root and angelica. It is also a product of albuminous decomposition; hence is present in old cheese and human excrement. It is usually obtained by oxidation of amyl alcohol. It is an oily, colorless liquid, and is soluble in alcohol.

Caproic acid, $C_5H_{11}.COOH$, is present in goat-butter; myristic, $C_{14}H_{28}O_2$, in nutmegs and cocoanuts; and caprylic in Limburger cheese and cocoanut-oil. Enanthylic acid, $C_7H_{14}O_2$, is present in oxidized castor-oil, and has an agreeable odor. Pelargonic acid, $C_9H_{18}O_2$, is found in geranium-leaves; lauric, $C_{12}H_{24}O_2$, in cocoanut-oil; arachidic, $C_{20}H_{40}O_2$, in peanuts; bycenic, $C_{22}H_{44}O_2$, in oil of benne; cerotic, $C_{27}H_{54}O_2$, in small grains free in beeswax; and melissic, $C_{30}H_{60}O_2$, in beeswax. True cerates always contain wax. The soap-like decomposition that dead bodies sometimes undergo is due to formation of adipocere, the NH_4 or Ca salts of cerotic acid. Stearin candles are a mixture of palmitic [$HC_{16}H_{31}O_2$] and stearic [$HC_{18}H_{35}O_2$] acids, both white, smooth solids.

Of the unsaturated, monobasic acids of the olefin series, oleic, $C_{17}H_{33}.COOH$, is most important. It is a constituent of fixed oils, and a by-product in the manufacture of candles. It is a colorless, oily liquid; tasteless, neutral (unless exposed to air); sp. gr., 0.9; insoluble in H_2O only (oleates of K and Na dissolve in H_2O). HNO_2 changes oleic acid to crystalline elaidin, and it solidifies spontaneously below 15°. It forms oleates with metallic oxids and alkaloids. Ricinoleic acid is an isomer of oleic.

Diatomic acids have the general composition $C_nH_{2n}O_3$ and may be considered diatomic alcohols in which one HO is replaced by COOH.

Glycolic acid, $CH_2.OH.COOH$, is a white, crystalline solid found in unripe grapes and leaves of the wild grape.

Lactic or oxypropionic acid, $C_2H_4OH.COOH$, is present in opium, ensilage, saùer kraut, gastric juice, and the gray matter of brain. It is produced by lactic fermentation of sugar (sour milk, koumiss, kefir). On a large scale it is made by digesting a mixture of sugar, milk, putrid cheese, and chalk at 30° for several weeks. The bacteria of the cheese act as a ferment, and the chalk, neutralizing the lactic acid formed, prevents an excess of this from stopping fermentation. The resulting $Ca(C_3H_5O_3)_2$ is decomposed with oxalic acid. The official acid is 75-per-cent. strength. It is a colorless, odorless, syrupy liquid; sp. gr., 1.2; optically inactive and generally soluble. Sarcolactic, or paralactic, acid is found in muscles (more after work), extract of beef, blood, and sometimes urine. It differs from ordinary lactic acid only in its dextrorotatory action on polarized light. A levorotatory acid is produced from cane-sugar by a special bacillus.

Identification of Lactic Acid.—A few drops of acid added to very weak solution of $FeCl_3$ gives a distinct yellow color. When the acid is floated on the iron solution, a sulphur-yellow ring appears.

Oxalic acid [$H_2C_2O_4.2H_2O(COOH.COOH)$] is found in many plants, as dock and wood-sorrel *(oxalis acetosella)* in the form of the K and Ca salts; in rhubarb, beets, etc., as the Ca salt. It is prepared artificially by oxidizing starch or sugar with HNO_3, or by fusing cellulose (sawdust) with caustic K or Na. It is a white, very sour, crystalline, sublime and poisonous solid, freely soluble in water, less so in alcohol. It is a strong reducing agent, and is used as a mordant in calico-printing, to clean Cu, as a solvent for Fe stains, and a precipitant for Au and Pt; also by workers in leather and makers of straw hats and bonnets. The Ca salt is very insoluble, and often gives rise to urinary calculi.

Experiment.—Make ink by mixing clear, aqueous solutions of tannin and $FeSO_4$, and decolorize with clear solution of $H_2C_2O_4$.

Succinic acid, $H_2C_4H_4O_4$, occurs in amber (succinum), lignite, and unripe grapes. It appears in colorless prisms with acrid taste, more soluble in water than in alcohol. It is sedative and diuretic. Commercially succinic acid is made by the action of reducing agents on tartaric acid.

Malic acid, $H_2C_4H_4O_5$ (oxysuccinic), is widely distributed in the vegetable kingdom in unripe grapes, apples, quinces, currants, gooseberries, rhubarb, etc. It appears in hygroscopic needles. The laxative effect of fresh cider is due to malic acid.

Tartaric acid, $H_2C_4H_4O_6$, occurs in four isomeric forms, namely: meso,- levo,- and dextro- tartaric and racemic (paratartaric) acids. The common dextro-acid is obtained from grape-juice, where it is both free and in combination with K and Ca. It is purified by neutralizing with chalk and $CaCl_2$, liberating with H_2SO_4, and crystallizing. The pure acid appears in colorless, monoclinic prisms of acid taste, soluble in H_2O and alcohol. On strongly heating, it chars quickly, giving off a distinct caramel odor. It is used in calico-printing and by confectioners to prevent crystallization of sugar. Racemic acid is a combination of equal amounts of two oppositely optically active agents, as shown by the opposite arrangements of the hemihedral faces of the two kinds of prismatic crystals obtained by evaporating a solution of sodium-ammonium racemate.

Identification of Tartaric Acid.—Neutral solutions give a white ppt. with $CaCl_2$, soluble (after quickly collecting on filter and washing) in KHO, but pptd. on boiling.

The basis of granular effervescent salts is a mixture of $NaHCO_3$ (83 to 85 parts) with a slight excess of citric (70) or tartaric (75 parts) acid and sugar. They are combined by heating a little above b.p. or by moistening and stirring mixed powders with alcohol, making the granules even by sifting after drying. Ninety grains of the finished salt equal a teaspoonful.

The tribasic acid, citric, $H_3C_6H_5O_7$, occurs free in lemons (6 per cent.), oranges, currants, cranberries, raspberries, gooseberries and tomatoes. The juice is purified by neutralizing with $CaCO_3$ and decomposing with H_2SO_4.

The Ca salt is present in wood, potatoes, and beets. The acid appears in large, colorless crystals, readily soluble in H_2O. Citric acid is used extensively in pharmacy to prevent pptn. of hydroxids from their salts in making scale preparations. Sugar or molasses is usually added to the pulp of tamarinds, to cover the sharp taste (9 per cent. citric acid).

Of the aromatic acids, benzoic and salicylic are most important. They are both sublime substances, antiseptics, and preservatives. Benzoic acid, $HC_7H_5O_2(C_6H_5.COOH)$, occurs in gum benzoin, cranberries, and the urine of herbivora. It is manufactured from toluene by treating with Cl, then H_2O. It appears in large needles, sparingly soluble in cold water, but freely soluble in alcohol. The synthetic product is odorless. Benzoic acid, changed to hippuric acid in the kidneys, is the only drug which can effectually render the urine acid (White).

Identification of Benzoic Acid.—After neutralizing, $FeCl_3$ gives a flesh-colored or reddish ppt.

Salicylic or oxybenzoic acid, $HC_7H_5O_3(C_6H_4.OH.COOH)$, is present in oil of wintergreen, senega, and coal-tar.

Experiment.—To some oil of wintergreen add five times as much liquor potassæ, and heat until completely saponified. Now add HCl and note ppt. of crystals of salicylic acid.

It is usually prepared synthetically by treating phenol with NaHO, and then the resulting NaC_6H_5O with CO_2; then heating without air to convert isomeric $NaC_6H_5CO_3$ into $NaC_7H_5O_3$; and finally treating with HCl to liberate the acid. Salicylic acid appears in fine needles of a sweet taste, sternutatory, and of acid reaction, soluble in 2.5 alcohol or 450 H_2O.

Identification.—Salicylic acid, even in very dilute solutions (1 in 500,000), gives violet odor with ferric salts. One part of Zn dissolved in 6 parts of HNO_3 produces a similar coloration, turning wine-red on boiling.

Cinnamic acid, $C_6H_5.CHCH.COOH$, occurs in storax and balsams of Peru and Tolu, to which it imparts the fragrant odor. It oxidizes readily to benzoic acid.

Test for Cinnamic Acid.—Boil with solution of NaHO, cool and acidulate with dilute H_2SO_4; add a little conc. $KMnO_4$ and note odor of bitter almond (benzaldehyd).

Official or gallotannic acid, $HC_{14}H_9O_9$, obtained by extracting nut-galls with ether and alcohol and evaporating solution, is a light-yellow, scaly compound; bitter, slightly acid, and strongly astringent; readily soluble in water and dilute alcohol. There are quite a number of closely related tannins (oak-bark, nut-galls, coffee, etc.). These all ppt. albumin and gelatin, tartar emetic, and most alkaloids, and form non-putrefying combinations with animal compounds, on which fact the process of tanning depends. The modern mineral method of tanning is by the use of CrO_3 and H_2SO_4, yielding a leather with a bluish tinge. Russia leather is any thin, smooth, finished leather impregnated with oil of birch.

Tannins produce black or blue-black ink with Fe salts, and hence are incompatible with these. A few vegetable bitters—namely: columbo, quassia, chiretta, and gentian—contain no tannin and may be prescribed with Fe solutions.

Experiment.—Note color of ppt. formed by solutions of tannic acid and lime water; tannin and $FeCl_3$ (no change with ferrous salts); tannin and KHO.

Gallic acid, $HC_7H_5O_5$ $[C_6H_2(OH)_3.COOH]$, is made by fermenting nut-galls or tannin:—

$$C_{14}H_{10}O_9 + H_2O = 2HC_7H_5O_5$$

It occurs in long needles, more soluble in alcohol than in water, and gives a blue-black ppt. with ferric salts, but does not coagulate albumin or ppt. gelatin or alkaloids.

Experiment.—Add a fragment of KCN to solution of gallic acid, and notice deep-rosy color.

Vegetable astringents owe their properties as such chiefly to some form of tannin, which ppts. proteins (not peptones in an acid medium) as digestible tannates. For intestinal effect it is better to give the colloid U. S. P. preparations (kino, catechu, krameria, hamamelis), or, still better, insoluble combinations with proteins (digested by pancreatic juice), so as to avoid local action on the stomach. The stools are rendered harder and firmer and diarrhea is checked. An excess, by irritating the bowels, may lead to loose stools. Tannic and gallic acids given by the mouth are absorbed to a slight extent as tannate or gallate of sodium, which has no astringent effect; hence these remedies are useless for remote hemorrhages (Cushny). Locally applied, tannin stops bleeding by coagulating the proteins of the blood, but only when brought into immediate contact with the bleeding point.

Phthalic acid [$C_6H_4(COOH)_2$] is a dibasic acid used as a source of the indicator phenolphthalein.

The relations of the various series of organic acids are shown by the following general formulas:—

Acetic: $C_nH_{2n+1}COOH$.
Hydroxacetic, or lactic: $C_nH_{2n}OHCOOH$.
Dihydroxacetic, or glyoxylic: $C_nH_{2n-1}(OH)_2COOH$.
Succinic: $C_nH_{2n}(COOH)_2$.
Hydroxysuccinic, or malic: $C_nH_{2n-1}OH(COOH)_2$.
Dihydroxysuccinic, or tartaric: $C_nH_{2n-2}(OH)_2(COOH)_2$.
Citric acid is expressed: $C_3H_4OH(COOH)_3$; that is, hydroxy-propane-tricarboxylic acid.

Hydrocyanic or prussic acid, HCN, is a colorless liquid with an odor like that of peach-blossoms; it changes to a gas at 26.5°. It is produced spontaneously by decomposition of amygdalin, a substance present in bitter cassava, cherry-laurel, wild cherry, bitter almonds, and the pits of stone-fruit. The United States Pharmacopeia preparation is a 2-per-cent. aqueous solution of the acid; the dose of this preparation is from 1 to 5 m. It is slightly acid, but very poisonous. $AgNO_3$ gives a white ppt. of AgCN, not darkening in the light. Boiled with an acid or an alkali, HCN splits into NH_3 and formic acid.

Identification of Hydrocyanic Acid.—Heated with a dilute solution of picric acid, HCN gives a deep red color on cooling. On exposing some filter-paper, treated first with fresh tinct. guaiac, then dried and soaked in very dilute $CuSO_4$—to the fumes of HCN, the paper turns a deep-blue color.

Chlor-acids are formed by replacing H of the acid radical with Cl; thus, monochloracetic acid is $CH_2Cl.COOH$. In thioacids the O of hydroxyl is replaced by S; in sulphonic acids, $ROHSO_2$, the hydroxyl H is replaceable by bases. Homologous acids can be formed from the cyanids of hydrocarbons through hydration by treating with a dilute acid or alkali. Cyanuric acid has the formula $C_3H_3N_3O_3$. Nucleic acids are classified according to the chief purin body which they yield on hydrolysis; thus, guanylic acid yields guanin. They contain up to 10 per cent. of P.

Of minor importance are erucic and benic acids (mustard), copaivic acid (copaiba), cubebic acid (cubebs), anthemic acid (matricaria), camphoric acid (prepared by heating camphor with HNO_3), igasuric acid (nux vomica), quinic acid (cinchona, grapes, cherries, strawberries), angelic acid (angelica), aconitic acid (aconite root), valeric acid (valerian, viburnum), and maizenic acid (corn silk). Chrysophanic acid (chrysarobin) is the active ingredient of goa. Filicic acid is the chief medicinal agent in male fern. It changes with age into its inert anhydrid filicin. Ergotinic and sphacelinic (N-free resinoid mixture of sphacelotoxin and ergochrysin) acids are present in ergot.

FATS AND FIXED OILS.

These are esters of glyceryl and the higher fatty acids, and are often termed glycerids. They are, for the most part, mixtures of triolein $[C_3H_5(C_{18}H_{33}O_2)_3]$, tripalmitin $[C_3H_5(C_{16}H_{31}O_2)_3]$, and tristearin $[C_3H_5(C_{18}H_{35}O_2)_3]$. The first is a liquid and the chief constituent of oils; the second, semisolid; the third, a hard solid (m.p. 63°). In plants (phytosterin) they are found chiefly in seeds and nuts; in animals under the skin and upon the viscera and muscles. Human fat is 67 to 80 per cent. olein (less olein in children), with a small quantity of free fatty acid. Olein and stearin are the chief constituents of most animal fats; olein, of vegetable oils (palm oil, chiefly stearin and palmitin).

They are usually obtained by expression or melting. So-called margarin is a mixture of palmitin and stearin. Plant oils are derived from CO_2 and H_2O; animal, from ingested fats, albumins and carbohydrates.

Pure fats are colorless, odorless, and tasteless. They leave a permanent translucent stain on glazed paper, on warming the paper in a test-tube. They differ from mineral oils in containing O, the proportion of which is low as compared with C (averages 76.5 per cent.). They are insoluble in water and nearly so in cold alcohol (except castor-oil, linseed and croton-oil), but are readily dissolved by ether, chloroform, gasolin, benzin, benzene, CS_2, etc. Castor-oil is insoluble in ether or petroleum ether. Fatty acids are less soluble than neutral fats, and require usually a mixture of ether and alcohol. Fats and oils are emulsified by soap, acacia, or albumins.

Experiment to Illustrate Emulsification (Brubaker).—Place on a few c.c. of 0.25 per cent Na_2CO_3 a small quantity of neutral oil, to which has been added 2-3 per cent. of a fatty acid. A soap is formed at once, and this quickly yields a spontaneous emulsion.

Solid fats melt below 100° and can be distilled without chemic change at about 300°, but are decomposed at higher temperatures into a number of products, of which the offensive smelling aldehyd acrolein, C_3H_4O (from glycerin), is most distinctive.

To Determine Melting-point of Fats.—Draw up a little of the melted fat into a capillary glass tube (can be made by drawing out ordinary size in flame), and attach this tube to the bulb of a thermometer. When the fat has congealed, the apparatus is held in a beaker of water, which is warmed gradually until the fat becomes transparent (melting-point).

Oils have a definite refractive index (average about 1.44—always greater than that of water), which is of signal aid in their identification.

By the iodin number of an oil or fat is meant the percentage by weight of I absorbed by a given weight of the oily substance. Thus, if 1 gm. of a certain oil absorbs 1 gm. I, its iodin number is 100.

Ordinary fats, containing albuminous matter, tend to become yellow and rancid, after a time, by liberation of fatty acids through fermentation and oxidation (forming oxyacids), even when bacteria are absent.

Drying or siccative oils (linseed, for example) are so called because they contain unsaturated acids, and harden by taking up O. Albuminous impurities, which prevent this oxidation, are removed by treating with 4 per cent. of H_2SO_4 and decanting the refined oil. Fats and oils burn readily, giving off a large amount of heat. When fats or oils are treated with alkaline hydroxids, glycerin is set free and a soap is formed, the process being termed saponification. When treated with ferments or superheated steam or boiling acidulated water, hydration takes place with formation of glycerin and a fatty acid. Fats and oils are used as foods and medicines and in paints and varnishes.

The purest olive-oil has a greenish tinge. On cooling to near f.p. it separates into crystalline palmitin and fluid olein. Cocoanut-oil contains less oleic acid than olive-oil and saponifies more readily.

Cottonseed-oil is pale yellow, and is used largely as an adulterant and substitute for olive-oil, butter and lard, as are also peanut (earthnut, arachis) and sesame (teel, benne) oils. Cottonseed-oil reduces $AgNO_3$ to the black, finely divided metal.

Both sweet and bitter almonds are about half oil and one-fourth proteid; also, in bitter almond, are the glucosid amygdalin (2 to 3 per cent.) and the ferment emulsin. This oil, by maceration and subsequent distillation, yields one-fourth as much hydrocyanic acid, to which its action is due principally. Oil of almond is usually straw-colored and should have no odor of bitter almonds. Cod-liver oil is quite complex. In addition to the fats, jecolein, palmitin, stearin, myristin and therapin, it contains a little cholesterin and gaduic acid, gadium, the alkaloids asselin and morrhuin, traces of I and Br, and various amins. It saponifies very readily, and hence is easy of digestion. The inferior grades are dark in color, owing to biliary matter. Pale cod-liver oil contains from 0.18 to 0.71 per cent. and the dark variety from 2½ to 5 per cent. of free oleic acid, which aids emulsion and digestion.

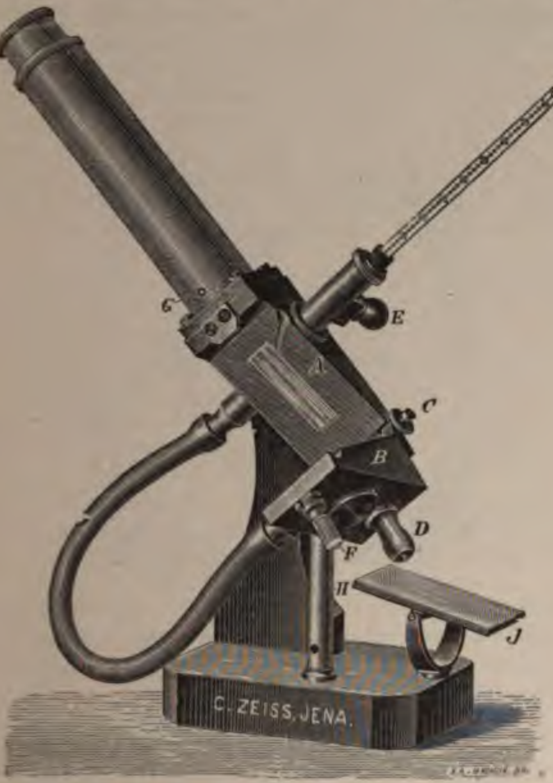


Fig. 35.—Zeiss's Butyrorefractometer.

Experiment.—Add to a little 3 p.m. solution of Na_2CO_3 a few drops of cod-liver oil. The mixture quickly becomes milky.

Linseed- or flaxseed- oil (35 per cent. of linum, with considerable mucilage and the amygdalin-like linamarin) is about 80 per cent. linoleïn [$C_3H_5(C_{18}H_{27}O_2)_3$]. Being unsaturated, it absorbs O and becomes gummy. Exposed in thin layers, it dries to a glassy solid.

Cottonseed, sesame, maize and rapeseed oils have also marked drying properties. The same glycerid is present in walnut, hempseed, sunflower, poppyseed, and nigerseed oils. The drying effect is much increased by boiling the raw oil in a current of air, sometimes adding oxid of Pb, Fe, or Mn, or borates. Linseed-oil is used in paints and printers' ink. The latter is a boiled linseed varnish containing lampblack or some other color and a little soap. Drying oils may, by absorbing O, cause sufficient heat to ignite rags or clothing soaked therewith. A mixture of japan and boiled linseed-oil (used as a filler in furniture) on a rag or on excelsior is certain to take fire within a few hours.

Castor-beans are nearly one-half oleum ricini, which is noted for its viscosity and nauseous taste. Castor-oil, on saponification by pancreatic steapsin, yields irritant ricinoleic acid, which differs from the free acids of ordinary fixed oils in being unsaturated and containing an OH group. Five-per-cent. castor-oil in petrolatum increases its absorptive power for H_2O fourfold (10 parts). Croton-oil contains a peculiar principle, crotonol, which excites a pustular eruption when applied to the skin. Croton-oil is a very energetic drastic cathartic, is changed in the small bowel into glycerin, and the very irritant crotonoleic acid; there is some free acid (much in old specimens) in the oil.

Lard-oil is "cold pressed": that is, extracted from lard at a low temperature. It is used in cooking. Benzoinated lard contains 2 per cent. benzoin, which retards rancidity. Sevum, from sheep, is used in cerates.

Butter contains in addition to 92 per cent. of olein, palmitin, stearin, myristin, and arachidin, the glycerids of butyric (7 per cent.), capric, caproic, and caprylic acids, which characteristic acids are volatile and soluble in water: a fact that is made use of in testing butter for adulteration. Butter contains, as a rule, 15 to 20 per cent. of water. The presence of buttermilk causes butter to decompose very rapidly.

Test for Butter.—Put a little in a test-tube and add two or three times as much alcoholic potash solution, and warm in the steam- or water- bath. Now add a few drops of H_2SO_4, and notice pine-apple odor of butyric ether.

Oleomargarin is a butter substitute prepared from the fat of omentum and mesentery of beef-cattle. This fat is hashed fine and then melted at about 50°. The liquid fat thus procured is kept in small vats at 27° for two or three days, to allow crystallization of the harder fats. From these yellow oleo-oil is obtained by pressure, and is churned with milk, colored, and rapidly chilled. Butterine has lard added to oleo-oil and milk before churning. Suin is a food-product similar to oleomargarin, using beef and mutton fat, and sometimes lard and cottonseed-oil.

Palm-oil is brown or reddish yellow and is between lard and tallow in consistence. Cacao-butter (oleum theobromatis) is a light-yellow, brittle solid with a pleasant odor, melting a few degrees (30°-33°) below the temperature of the body. It is used extensively as a basis for suppositories. A drop of glycerin added to each suppository (cold process) renders it more cohesive. White mustard seed has 25 per cent. of fixed oil; also sinapin sulphocyanid and sinalbin, which, by decomposition, yields an acrid, volatile oil. Black mustard has the same ingredients, except, in place of sinalbin, sinigrin, which, with water, splits into the volatile oil of mustard, a potassium salt and sugar. Digitalis leaves contain about 5 per cent. fat, which is said to delay absorption and irritate the stomach. A fixed oil is found in stillingia, pyrethrum, juglans and pareira root. Colchicum contains 6 per cent. of fixed oil; stramonium seeds, 25 per cent.; pumpkin seeds, 20-40 per cent.

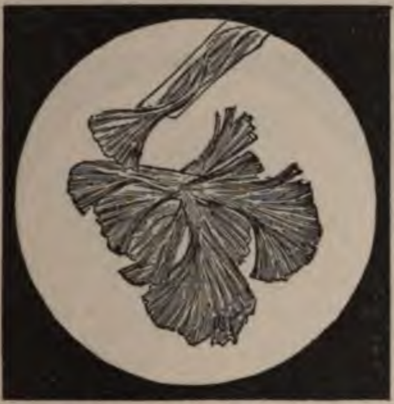


Fig. 36.—Lard, Crystallized from Chloroform.

The elaidin test for oils consists in shaking with nitrous acid, when, if positive, white, solid isomeric elaidins are formed. Olive-, almond-, benne-, mustard-, earthnut-, bone-, lard-, neat's-foot, tallow-, sperm-, doegling-, and dolphin- oils all react to this test. Drying oils (except castor) do not react to this test. Cottonseed and most other seed oils yield a more or less pasty mass, often with separation of a fluid portion.

Experiment.—Dissolve 1 c.c. of Hg in 12 c.c. of cold HNO_3 (1.42). Shake 2 c.c. of the freshly prepared solution with 50 c.c. of olive oil in a wide-mouthed, stoppered bottle, repeating agitation every ten minutes for two hours.

Lanolin, or wool-fat, is an ester of the cholesterins, $C_{27}H_{45}HO$. It is light yellow in color and has the odor of sheep's wool. It differs from ordinary fats in being miscible with twice its weight of H_2O, and it is also quite a stable product. The official hydrous lanolin contains not more than 30 per cent. of H_2O. Lanolin is very similar to human sebum. It is especially good for incorporating liquids in ointments. Any stickiness is overcome by adding a small proportion of liquid petrolatum.

Agnin is a similar preparation. A weak chloroform solution of wool-fat gives a brown ring in contact with H_2SO_4. Various cholesterols (phytosterols) are present in most seeds.

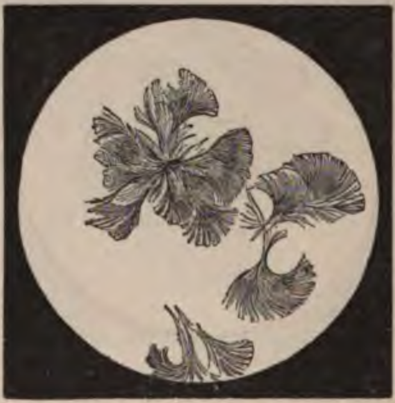


Fig. 37.—Human Fat, Crystallized from Chloroform.

Lecithins, or phosphorized fats, are found in nearly all cells, being most abundant in the brain and nerves, white blood-corpuscles and yelk of eggs (25 per cent. of vitellin). The one most frequent in the animal body has the empiric formula $C_{44}H_{90}NPO_9$—distearyl-glycerophosphate of cholin. Lecithin is soft and waxy, forming with H_2O a pasty mass, which under the microscope exhibits the "myelin" oily drops and threads. On decomposition lecithin yields H_3PO_4, some fatty acid (oleic, palmitic, or stearic), and an organic base, cholin. Lecithin can be pptd. from solution (and so separated from fat and cholesterin) by addition of acetone.

Waxes are compounds of fatty acids with alcohols other than glycerin. They are soluble in fat solvents and in boiling alcohol, but are not easily saponified. Cera flava (aut alba) consists chiefly of myricin, or myricyl palmitate, $C_{30}H_{61}O.C_{16}H_{31}O$. Spermaceti is made up largely of cetyl palmitate, $C_{16}H_{33}O.C_{16}H_{31}O$, and is used in ointments and cerates. Lactucarium has 50 per cent. wax. Fats in wax are detected by the acrolein odor on heating. The fixed oil expressed from sweet or bitter almonds is used, along with white wax and spermaceti, in the official ointment of rose-water.

SOAPS.

In the broad sense saponification is the decomposition of any ester by an alkali. Soaps are fatty-acid salts of various metals, generally obtained by boiling an hydroxid or oxid with a fat or oil: lard, tallow, olive, cottonseed, palm, peanut, etc.

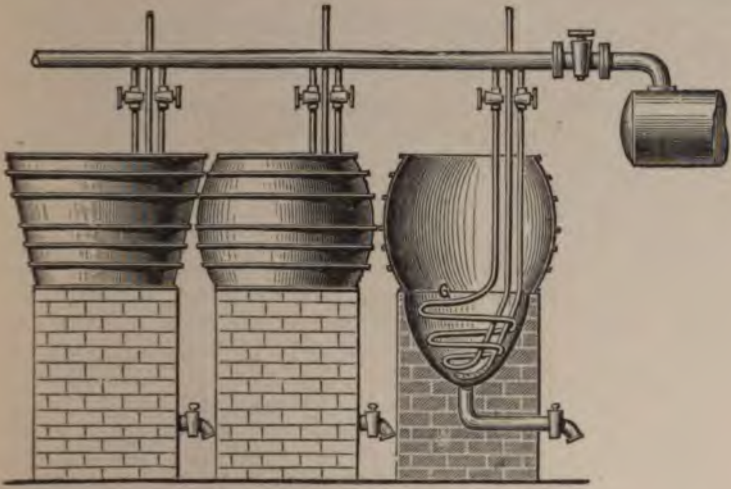


Fig. 38.—Soap Coppers.

Soft soap is a K compound; hard soap contains Na. The oil, the fatty acid, or the alkali may be in excess.

Experiment.—To 10 c.c. of olive-oil add one-fifth as much 10-per-cent. KHO. Boil and stir until mixture is homogeneous and no oil separates when a little is poured into water, keeping up original volume by adding H_2O. The resulting soft soap is converted into hard soap by adding saturated solution of NaCl and allowing to cool.

$$C_3H_5(C_{18}H_{33}O_2)_3 + 3KHO = 3KC_{18}H_{33}O_2 + C_3H_5(HO)_3$$
$$KC_{18}H_{33}O_2 + NaCl = NaC_{18}H_{33}O_2 + KCl$$

Common yellow or hard soap is sodium oleate; curd soap, sodium stearate.

K, Na, and NH_4 soaps are soluble in H_2O and alcohol, not in ether, but are thrown down by saturating with a neutral salt, as shown by the curd formed on adding common salt; all others are insoluble. Soaps are decomposed by mineral acids, which set free fatty acids, forming new salts. Transparent toilet soaps are made with castor-oil. Lard soaps are white and hard and often float on water. Glycerin is present in all soaps made by reaction between fats and alkalies; it is absent from soaps made with free fatty acids liberated by superheated steam. The common yellow soap is prepared with tallow or palm-oil and soda, and often also some rosin. Palm and cocoanut soaps take up much alkali, dissolve in salt-water, and are much used at sea. Cocoanut-oil is often added to a soap to make a good lather. Various coloring, odorous, medicinal, and polishing agents (sand, emery) are frequently added to soaps for special purposes. All soaps contain H_2O (from 20 to 80 per cent.), with which the smoothness varies.

Soaps treated with water decompose into an acid salt which ppts. and makes soapsuds with freed alkali, and a basic salt which dissolves and cleanses. When used in hard waters insoluble Ca and Mg soaps are first pptd. before there is any detergent action on the skin. These curds give the hard feeling to well water. Strongly alkaline soaps injure woolen fabrics by removing the natural fat of the fibers.

The official soap is white Castile, a Na soap made from olive-oil. The mottled appearance of some Castile soaps is due to $FeSO_4$. Ammonia liniment and lime liniment are fluid soaps prepared by mixing cottonseed-oil with NH_4HO (also 5-per-cent. alcohol) and linseed-oil with lime-water. Green soap (sapo mollis) is usually brown in color. It is a jelly-like potash linseed-oil soap made with the aid of alcohol. Lead plaster is chiefly lead oleate, and is prepared by reaction between soap and lead acetate in the presence of water. It is a pliable, tenacious mass, insoluble in water, soluble in ether. It is the basis of a number of official plasters. Ungt. diachylon has 50 parts of lead plaster, 49 of olive-oil, and 1 part of oil of lavender. In fusing for ointments and plasters the body having the highest m.p. should be melted first, then the others in order, stirring in any insoluble powder while cooling. Plasters are readily removed from the skin by moistening with alcohol, benzin, kerosene or gasolin.

CARBOHYDRATES.

Carbohydrates are compounds of C, H, and O, the two latter elements in the same proportion as in water, the C generally in 6's or some multiple thereof. They are derived by oxidation of hexatomic alcohols, and are in composition mostly penta-oxyaldehyds [$COH.(CHOH)_4.CH_2OH$ = dextrose] and penta-oxyketones [$CH_2OH.(HCOH)_3.CO.CH_2OH$ = levulose], or anhydrids of these. Some unimportant carbohydrates contain from 3 to 9 atoms of C.

Carbohydrates make up the greater bulk of plant-tissues; much less abundant in animals. With the aid of sunlight and chlorophyl plants build up formaldehyd, then sugar, then starch, cellulose, and proteins from the waste-products of animals. The mineral salts are similar in both plants and animals. The following equations represent a few synthetic results, without representing the complex intermediate steps:—

A hydrocarbon: $10CO_2 + 8H_2O = C_{10}H_{16} + 28O$.
A carbohydrate: $6CO_2 + 6H_2O = C_6H_{12}O_6 + 12O$.
An organic acid: $2CO_2 + H_2O = H_2C_2O_4 + O$.
A nitrogenous compound: $10CO_2 + 4H_2O + 2NH_3 = C_{10}H_{14}N_2 + 24O$.

Carbohydrates are mostly white and solid. All have a neutral reaction. They are generally soluble in H_2O, difficultly soluble in absolute alcohol, and insoluble in ether. Some are crystalline; others, more complex, are colloid. They sometimes form loose chemic combinations with bases. Unchanged or after treatment, they have a sweet taste, a reducing action on certain metals (Cu, Bi, etc.), and power to rotate polarized light and undergo alcoholic fermentation. They are readily oxidized in alkaline solutions, turning yellow or dark brown on heating.

According to their structure, carbohydrates are divided into three classes, the members of any one of which may be converted into those of another class by hydrolysis or dehydration:—

Polysaccharids (amyloses or amyloids: $(C_6H_{10}O_5)_{n(6 \text{ to } 200)}$. Mostly colloid.	Cellulose (cellulin). Lignin (wood). Tunicin (animal cellulose—ascidians and cynthians). Starch (amylum or glucosin). Dextrins (British gum). Inulin (levulin—rotates ray to left). Glycogen (liver-starch). Two to 16 per cent. Raffinose and lactosin (crystalloid). Gums. Related to pentoses, starches or dextrins.
Disaccharids (bioses or saccharoses): $C_{12}H_{22}O_{11}$. Crystalline and diffusible.	Sucrose (cane, beet, sorghum, maple, palm, sweet fruits). Lactose (milk-sugar, $C_{12}H_{22}O_{11}.H_2O$). Maltose (malt-sugar). Isomaltose (sweet extracts, amorphous).
Monosaccharids (aldoses and ketoses, glucoses, monoses, or simple sugars): $C_6H_{12}O_6$. Crystalloid.	Dextrose (grape-sugar, starch-sugar, glucose). Levulose (fructose, formose, diabetin). Galactose. Inosit (muscle-sugar; also derived from hexamethylene, C_6H_{12}). Arabinose (pectin sugar). Xylose (wood-sugar).

The building up of complex from simple sugars is termed reversion. Dextrose, lactose, and levulose polarize much higher when freshly prepared than after long standing; maltose, lower.

The correct reading may be quickly obtained by boiling or by adding a few drops of ammonia. Plant powders are generally best studied microscopically in temporary mounts of glycerin or saturated chloral hydrate solution (dissolves starch), which render the powders transparent.

General Test. Molisch's Reaction.—To a few c.c. of dilute syrup add a few drops of 15-per-cent. alcoholic solution of α-naphthol, and then add very slowly twice as much by volume of H_2SO_4 as of the sugar solution, sliding it down the side of the inclined tube. Note reddish-violet ring of furfurol. Nearly all albuminous bodies contain a carbohydrate molecule and give this reaction.

Cellulose, or plant-fiber, forms the cell-walls, or framework, of plants, and is the pulp, or indigestible part, of fruit. The trunks of trees contain also 6 or 7 per cent. of mineral matter. Pure cellulose is prepared by grating vegetable tissue (flax, cotton, hemp, wood, pith) and washing away the starch. Absorbent cotton (wax and fat extracted by alkaline hydrolysis, followed by bleaching acid oxidation) and filter-paper are nearly pure cellulose. It is soluble in ammoniated $CuSO_4$ (Schweitzer's reagent, from which it is pptd. as a white mass by acids), in CS_2, and in strong mineral acids, which convert it into dextrin. The fine, flexible, elastic fibers of cellulose are pressed or woven into linen, muslin, thread, ropes, paper (wood-pulp heated with NaHO or $MgSO_3$ under pressure), and *papier-maché.* When treated with H_2SO_4, cellulose is partly changed into a jelly-like glaze of hydrocellulose, or amyloid. Unsized paper dipped first, for a few seconds, into H_2SO_4 (equal volumes with H_2O), and then immediately washed (in water and then dilute ammonia) and dried, is converted into smooth, tough parchment-paper.

Mercerizing cotton consists in placing the fabric in a strong solution of caustic soda, which hydrolyzes cellulose. Cotton shrinks 20 per cent. and becomes 50 per cent. stronger, and has much greater dyeing capacity. If kept under tension so it cannot shrink, cotton takes a sheen like silk. Cellulose dissolved in hot $ZnCl_2$ solution makes a sticky syrup, which, when forced through a tiny orifice into alcohol, ppts. a fine thread, and this, when carbonized, makes a filament for incandescent lamps. Paper, soaked in the same solution and worked up, forms vulcanized fiber. Water-proof and bullet-proof goods are made from cellulose. Artificial silk is spun from "viscose," which is mercerized cellulose dissolved in CS_2.

Experiment.—The woody nature of stone cells (pears) is shown by staining first with alcoholic solution of phloroglucin, and then treating with HCl, when woody parts turn red. Chloriodid of Zn colors cellulose purple.

The nitrocelluloses are important explosive and combustible compounds prepared by treating cotton or paper with HNO_3 and H_2SO_4. Guncotton is the trinitrate [$C_6H_7O_2$-

$(NO_3)_3]$. Pyroxylin, or soluble guncotton, is the dinitrate $[C_6H_8O_3(NO_3)_2]$. The styptic fluid collodion is a solution of trinitrate and tetranitrate in alcohol and ether. Wood-silk is a mixture of cellulose and nitrocellulose. Celluloid is a smooth material prepared by incorporating pyroxylin with camphor and sometimes ZnO (yellow) or vermilion. Xylonite is a similar pyroxylin compound. Smokeless gunpowder is guncotton gelatinized with acetone or acetic ether and then dried and granulated; or guncotton mixed with nitrate of K and Ba; or guncotton combined with nitroglycerin; or picric acid (lyddite); or nitronaphthalenes. On destructive distillation cellulose yields CH_3HO, creosote, $C_2H_4O_2$, etc. Lignin is very similar to cellulose, and forms the inner lining of woody cells and vessels.

Cutin, cerin, and suberin are also like cellulose. They stain readily with anilin dyes (cellulose does not), and are liquefied on boiling with KOH. Oxycellulose is often formed by the action of bleaching (oxidizing) agents on cotton (becomes brittle and rotten). It reduces Fehling's solution on prolonged boiling, showing a rose-red color, due to Cu_2O.

Starch is present in all parts of plants, especially the seeds, roots, and tubers, where it serves as a food-supply for the young plant. The starch of green fruit turns to sugar (sucrose and invert sugar) in the process of ripening.

Rice contains 77 per cent. of starch; potatoes, 21; sago, 90; cereals, 50 to 70 per cent. It occurs in small grains in the cellulose cells, each kind having a different microscopic appearance according to its origin, 0.002 to 0.100 mm. in diameter, and concentric arrangement around nucleus. The starch is separated by grating, washing, and decanting. It is white, tasteless, amorphous, and slippery to the touch. It is insoluble in cold water. Hot water, alkalies, or ferments loosen the outer insoluble husk (farinose) and set free soluble granulose. Acids, heat, and ferments break starch down into dextrins, then isomaltose, maltose, and dextrose (ratio to starch 10:9). The conversion of starch into sugar by the action of dilute H_2SO_4 is an hydrolytic process, and is explained by the fact that H_2SO_4 diluted with H_2O forms orthosulphuric acid (H_2SO_4.-$2H_2O$), which, with the aid of heat, gives up the H_2O to the starch in the nascent state, as it were.

Starches are much used as food, in the manufacture of alcohol and glucose, and for stiffening paper and linen.

Experiment.—Change starch to sugar by boiling with a little H_2O and a drop of H_2SO_4. Note change in taste.

Test for Starch.—I gives a blue color to wet starch; brown to dry. This color, due to $C_6H_9IO_5I$, disappears on heating, and is partly restored on cooling. The color is likewise destroyed by adding anything which will form a compound with I, as Ag salts, alkaline hydrates, and sodium thiosulphate.

Starch grains present a polarizing cross—black on a white ground, or the reverse. Ginger differs from most other spices in containing starch (up to 45 per cent.). Amidulin is a term applied to soluble starch, which is obtained from starch by superheated steam and cooking with glycerin. It is a dextrin, but gives a blue color with iodoiodid of K solution. Inulin occurs in the roots of compositæ, replacing starch. It tends to crystallize out from alcoholic solutions, and is colored yellow by I. Digestive ferments have no action upon it, and it is used as a sweetening agent in diabetes.

Dextrin is intermediate between starch and glucose or maltose. It is a light-yellow, amorphous powder, quite soluble in H_2O, less so in alcohol. It rotates a ray of polarized light to the right. Amylodextrin ($C_{30}H_{50}O_{25}$) gives a violet color with I; erythrodextrin, a reddish-brown color; achroodextrin and maltodextrin give no color, but reduce Cu solutions slightly. Achroodextrin yields a white ppt. with alcohol. Dextrins differ from other polysaccharids in their power to dissolve $Cu(HO)_2$ in alkaline solution. Dextrin is manufactured on a large scale by heating starch for a short time at 160° to 250°. Dextrins are used as toast, bread-crust, infant-foods, mucilage, and bookbinders' paste, and in dyeing, calico-printing, postage stamps, finishing, and glazing of cards and wall-paper.

Glycogen, or liver-dextrin (15 per cent. in liver), imparts a sweet taste (on fermenting to sugar) to this organ, the carbohydrate reservoir, and is present largely in muscular tissues (2 per cent.) and oysters. It is a white, tasteless, amorphous powder, pptd. by alcohol and given a port-wine color by I. It is non-dialyzable, and forms an opaque mixture with water. Its sp. rot. power is $+ 196.6$.

In the botanic sense a gum means any vegetable exudation: as "gum" camphor, a stearopten; "gum" guaiac, a resin. Gums are amorphous, odorless, tasteless, viscid, translucent substances obtained as vegetable exudations or extracted by alkalies and pptd. by HCl and alcohol. They are derived from wandering sugars (levulose, maltose) in the sap. They have been produced by growing microörganisms on artificial media, and the yield of gums can be vastly increased by inoculating certain trees with cultures of proper bacteria.

The acacia type of gums, soluble in water, are compounds of Ca or Mg and K with arabic or gummic acid. The cerasin and bassorin groups are closely related to plant mucilages and pectin bodies. Gum arabic, or acacia, is the chief Ca salt of arabic acid, $C_{12}H_{22}O_{11}$; it is levorotatory, acid in reaction, and is the leading emulsifier in pharmacy. Acacia is due to a specific microbe, B. acaciæ. This gum is used in confectionery, dyeing and finishing silks and other fabrics, water colors, inks, matches and stationery.

Tragacanth is about one-half a soluble gum of the arabin series, and the other half insoluble bassorin, $C_6H_{10}O_5$. It absorbs several times its own weight of water, becoming soft, transparent and gelatinous. It is used for sizing and in mucilage, emulsions and troches (drug, sugar, tragacanth and flavor).

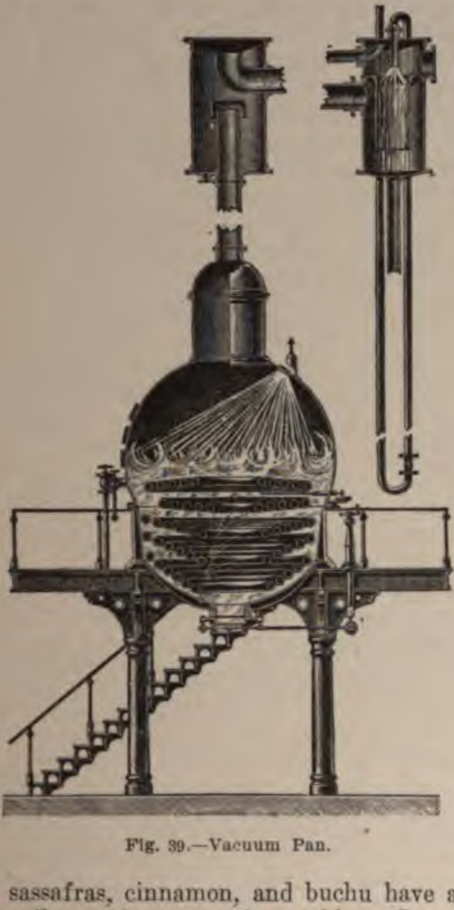


Fig. 39.—Vacuum Pan.

Ulmus, sassafras, cinnamon, and buchu have a noteworthy amount of mucilage. Agar-agar (vegetable or Japanese gelatin) is a gelatinizing material used by confectioners and bacteriologists. Other common gums are carrhageen (Irish moss), lichenin (Iceland and Irish moss), isolichenin (Iceland moss; resembles starch), cerasin (cherry-tree gum), marshmallow, flaxseed, and senegal. They form sticky mucilages with H_2O. Heating with HCl changes them to dextrose in part. They yield mucic acid when oxidized by HNO_3. Pectin, or vegetable jelly, constitutes the greater portion of Irish and Ceylon moss, and is the substance that causes vegetable juices to gelatinize. It is present in fleshy fruits and in roots, formed from insoluble pectose by the action of vegetable acids. Gums are used in medicine as demulcents. Mucilage is very avid of water; hence the use of flaxseed in the eye to wash out a foreign body.

Sucrose is obtained chiefly from cane and beets by crushing, then coagulating vegetable albumin and neutralizing acid by boiling with 1-per-cent. milk of lime, treating with CO_2, skimming, boiling with animal charcoal, filtering, and crystallizing in vacuum apparatus, the crystals being separated by centrifugation. The sugar remaining in molasses can be extracted by adding $Sr(HO)_2$ and passing in CO_2 to ppt. $SrCO_3$. Saccharose is sweet, and appears in large monoclinic crystals; sp. gr., 1.6; very soluble in H_2O (0.5 cold); insoluble in strong alcohol, ether, or chloroform. It is inverted—*i.e.*, converted into dextrose and levulose—by boiling, acids, or ferment action; even strongly acid fruit-juices have power to invert sucrose.

$$\overset{+66.5^\circ}{C_{12}H_{22}O_{11}} + H_2O = \overset{+52.5^\circ}{C_6H_{12}O_6} + \overset{-94.4^\circ}{C_6H_{12}O_6}$$

Cane-sugar melts at 160° and cools into clear, glassy barley-sugar. At higher temperatures it turns yellow, forming dextrose and a gummy substance called levulosan. On heating still further (200°) it gives off gases and darkens into brown caramel from loss of H_2O, being finally reduced to one-third its volume of coke. H_2SO_4 also chars cane-, but not grape- or milk- sugar. Cane-sugar does not undergo alcoholic fermentation, except indirectly through invertase, and does not respond to the copper tests. It forms insoluble sucrates or saccharosates with Ca, Ba, and Sr hydrates. It is used in food, syrups, preserves, and wines. Caramel is employed to color liquors, vinegars, confectionery, etc. Beet-sugar differs from cane-sugar only in being lighter in equal volumes. The official syrup is made by either the hot process or the cold (percolation), and should have a sp. gr. of 1.26 when hot; 1.32 when cold.

Experiment.—Change cane-sugar to glucose by dissolving a few grains in H_2O, adding a drop of H_2SO_4, and boiling ten or fifteen minutes. Prove that this product reduces alkaline $CuSO_4$ solution, changing the color from blue to yellow, then red, whereas cane-sugar solution has no such reducing effect.

Lactose constitutes 3 to 7 per cent. of milk, and is a byproduct in the manufacture of cheese, the whey being evaporated and the sugar collected on strings and sticks. It is slightly sweet; sp. gr., 1.5; soluble in 6 parts of water. It undergoes lactic and alcoholic fermentation (with kefir, not pure yeast) and responds to the glucose reduction tests. Dilute acids convert it into galactose and dextrose. Owing to its hardness and grittiness, it is widely utilized in powders and tablet triturates.

Maltose is obtained from starch by diastatic fermentation, or by boiling with dilute H_2SO_4. The same change takes place spontaneously during the germination of seeds. It appears in white needles soluble in both water and alcohol. On hydrolysis it breaks up into two molecules of dextrose. It ferments with yeast to alcohol and responds to the glucose reactions. Maltose and lactose are distinguished from glucose by not reducing Barfoed's reagent (solution of cupric acetate in acetic acid).

Dextrose makes up 10 to 50 per cent. of grape-juice, and is widely distributed in vegetables (raisins, figs, and other sweet fruits) and honey, usually with an equal amount of levulose and some maltose and dextrin, the mixture being known as invert-sugar. It is produced in plants from starch by the action of vegetable acids, and is also present with sucrose in beets and other roots. It is the form in which carbohydrates are absorbed into the blood, and is present in diabetic urine. It is manufactured on a large scale by heating starch or cellulose with dilute acids (1 per cent. H_2SO_4), excess of acid being removed with chalk. It is crystalline (small cubes or square plates) if anhydrous; it is only half as sweet as sucrose, and soluble in its own weight of water and in dilute alcohol. With yeast it ferments to alcohol and CO_2, and also may undergo lactic-acid (in presence of milk or cheese) or butyric-acid fermentation.

$$C_6H_{12}O_6 = 2C_3H_6O_3 \qquad 2C_3H_6O_3 = C_4H_8O_2 + 2CO_2 + 2H_2$$

By oxidation it is changed to saccharic ($C_6H_{10}O_8$, isomeric with mucic acid) or oxalic acid. It is a strong reducing agent (1 molecule $= 5CuO$). It aids the solution of lime in water. It is used in food as syrups and in preserves, confectionery, and artificial honey; also in printers' rollers and copying inks.

Experiment.—Show reducing action of dextrose on an alkaline aqueous mixture of some Bi salt. Note the change from white to gray or black.

Levulose occurs with dextrose as invert- or fruit- sugar. The purest is obtained from inulin. It appears as needle-shaped crystals or a thick syrup, which prevents dextrose from crystallizing. It responds to the dextrose test with two-thirds as much reducing power. Both dextrose and levulose can be prepared synthetically (acrose) from HCOH by treating with milk of lime. It is used as a substitute for cane-sugar in diabetes, since it is readily oxidized. Many fruit juices become levorotatory when fermented, since dextrose ferments more readily than levulose.

Honey (mel) is a syrupy solution (levorotatory) of dextrose and levulose, with particles of wax. Nectar is sucrose. Levulose can be separated from dextrose by adding slaked lime to the solution, pptg. levulose, filtering, and pptg. lime with CO_2, leaving dextrose in solution.

Test for Levulose.—Dissolve resorcin in 20 per cent. HCl and heat a little of this with solution to be tested, getting a red color; also a ppt., which dissolves in alcohol with a red color.

Galactose is obtained from lactose or gums by hydrolysis, and is present in koumiss and kefir. It does not ferment with yeast, but reduces Cu solutions. On oxidation it is changed into mucic acid.

Many unimportant compounds are produced by the oxidation of hexatomic alcohols. Rhamnose has the formula $C_6H_{12}O_5$; glycerose, $C_3H_6O_3$; erythrose, $C_4H_8O_4$; mannose (from mannite), $C_6H_{14}O_6$. Pentosanes are plant-products yielding pentoses by hydration. Inulin, from elecampane, is an example; arabinose, $C_5H_{10}O_5$, is another. Scyllite is a sugar obtained from fishes. Bioses and trioses are composed of 2 or 3 molecules of glucose with H_2O. On heating invert-sugar with dilute mineral acids it yields levulinic acid, $C_5H_8O_3$, and humous substances. Melitose or raffinose is a trisaccharid, $C_{18}H_{32}O_{16}$.-$5H_2O$. It is present in manna and in sugar-beets.

GLUCOSIDS, OR COMPOUND SUGARS.

The glucosids are compound ethers which, under the influence of ferments or dilute acids or alkalies take up H_2O and split into glucose and other products. They are generally neutral, soluble (except in ether), and crystalline. Many are optically active (levorotatory). Some contain N. They are usually of vegetable origin (often accompanied by a ferment) and are extracted with water or alcohol, decolorized with animal charcoal and crystallized. They can be made synthetically from glucoses dissolved in alcohol, into which HCl gas is passed. They are incompatible with free acids, alkalies, or ferments. Their names nearly all end in *in* (Latin, *inum*)—exceptionally in *etin*, *egol*, or *idin*.

The neutral principles (glucosidal and nitrogenous) of plants include some of the most important remedies. The glucosids may be of service to the plant as potential sugars. Saponins are strong emulsifying agents and are important constituents of digitalis, senega, sarsaparilla, squill, guaiac, quillaja. The tannins are extremely abundant, occurring chiefly in barks and leaves, sometimes in globular masses. The juice of opium has no starch or tannin, while that of catechu has 40 per cent. tannin; pinus canadensis, 14 per cent.; kino and red gum, 45 to 55 per cent. The purgative derivatives of anthraquinone comprise emodin (rhubarb, aloes, senna, frangula) and the neutral "chrysophanic acid" (senna, cascara sagrada, rhubarb). These dissolve readily in alkalies (set free by alkalies of intestine), giving a red color (alkaline urine).

Absinthin.—Bitter principle of wormwood. **Absinthe** is sweetened dilute alcohol flavored with oil of wormwood and colored with chlorophyl.

Adonidin.—Adonis vernalis; cardiac tonic.

Agaricin.—From white agaric, a poisonous mushroom; checks hyperidrosis.

Amygdalin ($C_{20}H_{27}NO_{11}$).—White, crystalline powder; bitter almond, cherry-laurel, etc.; dilute acids convert into dextrose, benzoic aldehyd, and HCN; same change spontaneous in aqueous extracts, owing to action of ferment emulsin.

Apocynein and Apocynin.—From apocynum.

Arbutin.—Uva ursi; bitter diuretic. Yields hydroquinone.

Asparagin.—Asparagus; diuretic.

Baptisin.—Baptisia tinctoria; purgative.

Bryonin.—Bryonia-root; hydragog.

Cactin.—Cactus grandiflora; acrid, resinous cardiac tonic.

Cathartic Acid.—Senna and rhubarb. Cathartic acid is really a mixture of the anthraquinones emodin, isoemodin, and chrysophanic acid.

Cerebrin.—Brain- and nerve- tissue; yields galactose or cerebrose.

Chitin.—Shells of crustaceæ.

Chrysophan.—Rhubarb. Chrysophanic acid is formed from the glucosid chrysophan in the presence of water; alcoholic extracts are free from it.

Cimicifugin.—Cimicifuga; bitter.

Colocynthin.—Colocynth-fruit; purgative.

Coloring Principles.—See "Indican," "Carminic" and "Ruberythric Acids," and "Xanthorhamnin."

Coniferin.—Woody tissue of sugar-cane and cambial juice of coniferæ; yields vanillin with CrO_3.

Convallamarin.—Convallaria; heart-tonic.

Convolvulin.—Jalap; drastic purgative.

Cotoin.—Active principle of coto.

Digitalin ($C_5H_8O_2$).—White, amorphous, bitter substance from leaves of fox-glove; soluble in 1000 H_2O or 100 dilute alcohol; yellow solution with HCl. Digitalis leaves contain the glucosids digitoxin (active and very toxic, soluble in alcohol) and digitophyllin; also the body digitonin (amorphous, yellow, soluble in water; diuretic only). The seeds contain digitalin and very little digitoxin. The digitalins of commerce are usually a mixture of some of these bodies and their decomposition products. The glucosids of digitalis are more soluble in water than in alcohol, digitonin serving as a saponin principle to render the others absorbable. Digitalin is the chief constituent of amorphous digitalin; digitoxin, of the crystalline. In old infusions and when the leaves are stored damp, digitalin, digitalein, and digitoxin decompose into resins acting like picrotoxin.

Test for Digitoxin.—To a very dilute solution in 5 c.c. of dilute acetic acid, add one drop of very dilute $FeCl_3$, and pour at once upon H_2SO_4. It shows a contact band of blue-green, becoming a dark blue (red-brown toward H_2SO_4); the acetic acid gradually turns green. Digitalin can be removed from alcoholic or aqueous solutions by agitating with freshly pptd. $Pb(OH)_2$. The lead ppt. takes on a flesh color on treating with H_2SO_4, turning a bright green on adding Br water. On evaporating a solution of commercial digitalin with a drop of H_2SO_4, we get a reddish-brown color, which turns violet on exposing to vapors of Br.

Dulcamarin.—From dulcamara.

Emodin.—Bark of cascara (cascarin) sagrada (3 per cent.), aloes, rhubarb and senna leaves; bitter laxative.

Ergotinic Acid.—A sapotoxic nitrogenous glucosid in ergot.

Esculin.—Bark of horse-chestnut.

Frangulin, or Rhamnoxanthin. — Bark of cascara sagrada (16 per cent.); tasteless laxative, as active as emodin; extracted with water and ammonia, condensed on water-bath, rendered alkaline with milk of lime (acids ppt. cascara).

Fraxin.—Ash-bark. Fluorescent.

Gentiopicrin and Gentisin.—Gentian-root. React like tannin with iron.

Glycyrrhizin.—Licorice-root; quinin and acids incompatible—form resinoid bitter and sugar, like glucose.

Gymnemic Acid.—Kavali, mera-singi, $C_{32}H_{55}O_{12}$; from gymnema sylvestris; white, soluble powder; temporarily destroys taste for sweet and bitter.

Helenin.—Elecampane.

Helleborin and Helleborein.—Black and green hellebore.

Hesperidin.—Orange-peel; bitter.

Jalapin.—In scammony and jalap-resin; soluble in ether.

Test for Convolvulin and Jalapin.—Dissolve in H_2SO_4, getting with convolvulin a bright-red color, turning olive-green on adding a fragment of $K_2Cr_2O_7$. Jalapin yields a maroon color on dissolving; a reddish color and rancid butter odor on adding $K_2Cr_2O_7$.

Leptandrin.—Leptandra, or Culver's root.

Myronic Acid ($C_{10}H_{19}NS_2O_{10}$).—In black mustard as K salt (sinigrin); this salt decomposed by ferment myrosin as follows:—

$$KC_{10}H_{18}NS_2O_{10} = C_6H_{12}O_6 + \underbrace{C_3H_5NCS}_{\text{allyl mustard-oil}} + KHSO_4.$$

Mustard plasters are rendered inert by boiling water, which coagulates ferment myrosin and prevents formation of sulphocyanate, to which the mustard owes its virtue.

Phloridzin.—Root-bark of apple, pear, plum, and cherry; causes glycosuria.

Phloridzin ($C_{21}H_{24}O_{10}$) + H_2O = phloretin ($C_{15}H_{14}O_5$) + $C_6H_{12}O_6$.

Picrococin.—In saffron.

Podophyllotoxin.—Chief active principle of podophyllum.

Test.—Both podophyllin and podophyllotoxin can be removed from an acid aqueous liquid by shaking with chloroform. Both are colored dark yellowish-green by Mandelin's reagent (0.5 ammonium vanadate in 100 H_2SO_4).

Populin.—Bark and leaves of trembling-poplar; with benzoic acid.

Quercitrin.—Sumach and grape-vine and oak and other barks; coloring principle.

Salicin ($C_{13}H_{18}O_7$).—Willow-bark and leaves; combination of $C_6H_{12}O_6$ and oxybenzyl alcohol, $C_6H_4OH.CH_2OH$; white, crystalline, soluble in 28 H_2O or 60 alcohol; H_2SO_4 turns deep red.

Santonin ($C_{15}H_{18}O_3$).—Wormseed; shining, colorless prisms, turned yellow by light; sparingly soluble in H_2O, but more so in alcohol and ether.

Identification of Santonin.—Warm on porcelain and add H_2SO_4 and an equal volume of very dilute $FeCl_3$. A red color is developed, turning purple, then violet.

Saponin.—Quillaja, senega, sarsaparilla, horse-chestnut, etc.; white, friable powder; frothy foam, like soap. The sapotoxins are physiologically active.

Identification of Saponin.—Canary color on adding a drop of conc. H_2SO_4, gradually turning purple on moistening with H_2O, bleaching after some hours.

Scammonin.—Scammony-resin; soluble in ether.

Scillitin.—Squill-bulbs; expectorant and diuretic. Scilla contains scillin, scillain, scillitoxin, scillipicrin and sinistrin; also considerable mucilage and raphides of CaC_2O_4.

Scoparin.—Scoparius; heart-tonic.

Solanin.—Solanum species and potato-sprouts; poisonous.

Sinalbin.—White mustard.

Strophanthin.—Seed of African climbing plant, used for arrow-poison; heart-tonic.

Test.—Strophanthus gives a green color with H_2SO_4 (80 per cent.), fading through blue to red. Strophanthin yields a red color when treated first with sodium nitroprussid and then with an alkali. It dissolves in 75 per cent. H_2SO_4 with a fine violet color (sensitive to 0.5 mg.). An aqueous solution treated with a trace of $FeCl_3$ and then with conc. H_2SO_4, yields a brown ppt., turning emerald after an hour or so.

Tannin ($C_{14}H_{10}O_9$).—Wide distribution; acid reaction; soluble, astringent, bitter; incompatible with nearly everything; tea, leather, inks, dyeing. Styptic collodion, a saturated solution of tannin, is a valuable styptic, particularly for bleeding gums. Tannin yields dextrose and gallic acid on hydrolysis. Pathologic tannins give a blue-black color with ferric salts physiologic, a green-black.

Experiment.—Boil 1 gm. of tannin for fifteen minutes in 10 c.c. of 5-per-cent. H_2SO_4; then neutralize with excess of marble-dust and test filtrate for glucose.

Taraxacin.—Taraxacum; bitter.

VEGETABLE COLORING MATTERS.

The coloring matters of plants are of no direct therapeutic value, and appear to be chiefly benzol derivatives. The brown phlobaphenes, or resinoids, give color to most barks. Color granules are often visible with the microscope—bright-yellow berberin in golden seal; red granules in sanguinaria. Some woods (logwood, santal) contain colorless crystals, which turn red on oxidation. If leaves dry very slowly, oxidases and organic acids change their color to yellow or brown. The bright color of chlorophyl is retained by some secret process—boiling a solution tends to preserve the color. Red hues (often interchanging with blue) serve as a protection against cold, and frequently appear after wounds of the plant tissues. They are most prominent in plants and parts of plants rich in sugar. Red colors are changed to green by NaHO if due to fruits; to blue or purple when of other vegetable origin. Anilin dyes are usually not changed.

Litmus.—A lichen; litmic acid, red; salts, blue. This and other lichens are extracted by mixing with urine (ammonia develops dye) for some time, then saturating with chalk. Litmus contains azolitmin (blue; soluble in water) and erythrol (soluble in alcohol), which should be removed with boiling alcohol.

Archil and Cudbear.—Lichen dyestuffs; orcin (dihydroxytoluene) in former changed into orcein by treating with NH_4HO.

Curcumin.—Resin of turmeric root; yellow color, turned red-brown by alkalies; soluble in $CHCl_3$ (saffron and mustard not) and in alcohol (not in water); used to color mustard, chow-chow, and vermicelli.

Chlorophyl.—Resinoid mixture of xantho- and erythro- $(C_{40}OH_{64}N_2O_4)$; combined with Fe; necessary to life and growth of plants; soluble in alcohol and ether, but not in water. Chlorophyl transforms red rays into chemic energy. The various color tints of leaves and fruits are due to the mingling of chlorophyl, xanthophyl, and erythrophyl.

Hematoxylin.—Logwood; yellow solid, red liquid; dye and section-stain.

Kramerin.—Reddish coloring matter in krameria.

Carthamus. — Safflower; contains yellow and red (carthamin) principles, the latter soluble in alcohol, not in water.

Alkanet.—Contains alkanet red, or anchusin, used for coloring tinctures and oily liniments.

Carminic Acid.—Coloring constituent of cochineal (dried female insects on cactuses); carmin prepared by extracting cochineal with H_2O and pptg. with alum and lime—reddish-purple magma soluble in water and alcohol and NH_4HO. Face-rouge is carmin with starch or French chalk; lac-dye is a cheap form of cochineal.

Indican.—In woad and indigo plant; acids or fermentation change to indigo-blue and indiglucin. Indigo-blue or indigotin ($C_{16}H_{10}N_2O_2$), insoluble in alcohol, water, or ether; soluble in H_2SO_4 or $CHCl_3$; reduced to indigo-white ($C_{16}H_{12}N_2O_2$) by nascent H; has been prepared synthetically from toluene or naphthalene. Indigo includes i. blue, i. red and i. brown. Its sp. gr. is 1.4, but it floats on water. It sublimes with a disagreeable odor. When indigo-blue is oxidized it is changed to isatin, which is yellowish-brown—a test for HNO_3.

Experiment.—Render a dilute solution of lactose blue with indigo-carmine, and make alkaline with Na_2CO_3. On heating, by deoxidation, the blue color becomes red, then yellow and nearly colorless. On cooling and reoxidizing, by pouring the solution repeatedly from one test-tube into another, the colors reappear in reverse order.

Ruberythric, or Rubianic, Acid. — A glucosid in madder-root; yields by fermentation alizarin (turkey-red) and purpurin.

Xanthorhamnin.—Coloring matter of buckthorn, or *Rhamnus tinctoria.*

Bixin and Orellin.—Red and yellow scales, fruit of *B. orellana;* colors yellow (annatto or annotto—butter). H_2SO_4 gives a blue color, turning yellow on adding water.

Brasilin.—Brazil wood; amber yellow; fused with KHO yields resorcin.

Saffranin, or Crocin (Polychroit).—Glucosid in saffron, or crocus; colors food yellow. Conc. H_2SO_4 gives a marked blue color with genuine crocus.

Santalin.—Crystalline resinoid in red saunders wood; also barwood and camwood. Used in pharmacy for coloring tinctures.

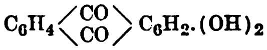
Kamala contains a red coloring matter; catechu and kino, each a red dye. Other natural vegetable coloring matters are those in fustic, or yellow, wood; Persian berries (rhamnin); quercitron bark (quercitrin); weld (luteolin); and buckthorn berries (sap-green, bladder-green, Chinese-green, lokas).

COAL-TAR COLORS.

The synthetic coal-tar colors (mostly from benzene) have high coloring power, and are, as a class, soluble in water or alcohol. Common types are nitro- and nitroso- colors (naphtol yellow, naphtol yellow S, naphtol green, picric acid), Soudan or azo- colors (methyl-orange, Bismarck brown, Congo red), thio-compounds (methylene-blue, $C_{16}H_{18}N_3SCl$), and phenylmethane derivatives (malachite-green, magenta or fuchsin, eosins, rhodamins, methyl-violet or pyoktanin-blue, phenolphthalein). Affixed letters usually refer to shades of color, as J (jaune, yellow), JJ (stronger yellow), O (orange). S usually indicates sulphonation.

Basic anilin dyes are employed chiefly in bacterial stains; neutral and acid dyes, also in examining tissue cells. Basic dyes may be separated from alkaline (KOH) solutions by shaking out with ether; acid dyes also with ether, after acidulating with acetic or hydrochloric acid. Anilin dye stains are removed by washing with soap (or ammonia), then alcohol.

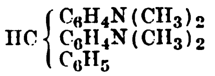
Alizarin (orthodioxyanthraquinone)



$$C_6H_4\left\langle\begin{matrix}CO\\CO\end{matrix}\right\rangle C_6H_2.(OH)_2$$

is obtained from madder-root *(Rubia tinctoria)*; now usually formed by synthesis from anthracene. Fine red crystals, readily soluble in alcohol and ether. Turkey-red dye; violet or purple with alkalies; various colored lakes with metallic oxids: red with Al and Sn, violet-black with Fe, reddish blue with Ca. Naphthazarin, or alizarin-black, is dioxynaphthoquinone [$C_{10}H_4(OH)_2O_2$]. Alizarin-orange is obtained by the action of N_2O_4 on alizarin; alizarin-blue by heating alizarin-orange with glycerin and H_2SO_4. Alizarin-brown, or anthragallol, is an isomer of purpurin, or trioxyanthraquinone [$C_{14}H_5(OH)_3O_2$].

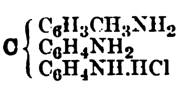
Triphenyl-methane Coal-tar Dye-colors.—*Malachite-Green Group of Diamido Derivatives.*—Malachite-green (colorless base):—



$$HC\left\{\begin{matrix}C_6H_4N(CH_3)_2\\C_6H_4N(CH_3)_2\\C_6H_5\end{matrix}\right.$$

Commercial dyestuff: chlorhydrate or $ZnCl_2$ double salt.

Rosanilin Group.—Fuchsin, or magenta; chlorhydrate of rosanilin:—



$$C\left\{\begin{matrix}C_6H_3CH_3NH_2\\C_6H_4NH_2\\C_6H_4NH.HCl\end{matrix}\right.$$

Pyoktanin-blue (methyl-violet) is penta- and meta-methyl-rosanilin hydrochlorid. It is antiseptic and analgesic, and is used for wounds, ulcers, and malignant growths. Pyoktanin-yellow (apionine, medicinal auramine) is also antiseptic, and is used in skin diseases. Methyl-blue is poisonous; methylene-blue is medicinal. A small quantity of NaHO added to a methyl-blue solution (blue) turns it purplish-red, while a methylene-blue solution (green) becomes a deep-violet color.

Phthalein Group.—Produced by reaction of a molecule of phthalic anhydrid [$C_6H_4(CO)_2O$] on 2 molecules of phenol. with liberation of H_2O. Phenolphthalein is an indicator for alkalies ($C_{20}H_{14}O_4$); fluorescein, or resorcin-phthalein, is used as the Na salt (uranin) to dye wool yellow; eosin is the K salt of tetrabrom-fluorescein, and dyes silks and woolens reddish. The rhodamins are phthalein derivatives of 1-3 amidophenol. Erythrosin is tetraiodofluorescein. Methyl-orange is dimethyl-amido-azo-benzol sulphonate. Soudan I, or anilin-azo-β-naphtol, is an orange-red color sometimes employed in liquors. Naphtol-yellow (Martius') is dinitroalphanaphtol; naphtol-yellow S is a sulphonated derivative. Scarlet red, the Na salt of amidoazobenzeneazobetanaphtoldisulphonic acid, is used as an ointment in the treatment of ulcers.

NEUTRAL BITTER PRINCIPLES.

Aloins.—Yellow, bitter, minute needles from *Aloes Barbadensis* or *Socotrina* (12 per cent.); slightly soluble in water, but more so in alcohol; barb-, soc-, or nat- aloin.

Identification of Aloin.—Dissolve in strong H_2SO_4 and a little HNO_3, and dilute with H_2O: A yellow color (blue, nataloin; no color, socaloin), turning deep claret with excess of NH_4HO.

Cantharidin ($C_{10}H_{12}O_4$).—Spanish-fly blister.

Cimicifugin.—Black snakeroot.

Cotoin.—Bolivian coto.

Cubebin.—Cubeb-berries; neutral, waxy, inert.

Elaterin ($C_{20}H_{28}O_5$).—Neutral principle deposited by juice of "squirting cucumber" (44 per cent. of elaterium); most powerful hydragog known. Elaterin yields a carmine color on treating with H_2SO_4 containing a trace of phenol.

Euonymin.—Wahoo-bark.

Phytolaccin.—Crystalline substance from poke- root and fruit.

Picrotoxin.—Crystalline bitter convulsant from *Cocculus Indicus.*

Serpentaria.—Virginia snakeroot.

Quassin.—Quassia-bark; simple bitter.

Euonymin is the bitter principle of euonymus; viburnin, of the viburnums; villosin, in rubus; daphnin, in mezereum; nucin, in juglans. The neutral active principle (kosotoxin) of cusso is present only in the female inflorescence. Capsaicin, the most important part of capsicum, is a neutral crystalline principle extracted with benzin or gasolin. Colocynth has 6 per cent. of the active bitter body colocynthin, which, by decomposition, yields colocynthein (still more active). Bitter principles are pronounced in marrubium (marrubiin), chirata (ophelic acid), scutellaria (a glucosid), rhubarb (rhein—cathartic principle), arnica (arnicin), calamus (acorin), cascarilla (cascarillin), licorice (glycyramarin), and buchu (barosmin, or diosmin; diuretic). Chrysarobin stains can be removed with dilute KOH.

PHENOLS.

These are substitution products of benzene, in which one or more atoms of H are replaced by OH. They stand between organic acids and true alcohols; they differ from alcohols in not oxidizing to aldehyds and acids, but they form ethers.

Phenol (phenic, phenylic, or carbolic acid, hydroxybenzoxybenzene), $C_6H_5.OH$, is manufactured from coal-tar oil distilled at 150° to 190°. It is purified by treating with lime and HCl, and by repeated distillation. It appears in crystals with characteristic aromatic odor and sweet, burning, and numbing taste. It fuses at 35° to 41°; b. p., 178°, and is liquefied by .08 part and soluble in 20 of H_2O and in nearly every other solvent. It is neutral or faintly acid. It coagulates albumin and collodion. Phenol is a valuable surgical antiseptic, but very poisonous. The salts of phenic acid are termed phenates or carbolates, as NaC_6H_5O.

Identification of Phenol.—$FeCl_3$ gives a permanent violet color. Alcohol, ammonia, mineral acids and some neutral salts interfere with this reaction. Br water gives white ppt. of tribromphenol.

A fourth volume NH_4HO and 1 or 2 gtt. NaClO solution on warming give a blue or green color, turning red on acidulating with HCl. $FeSO_4$ shows a violet color.

Cresol (cresylic acid), $C_6H_4.CH_3.OH$, is obtained from coal-tar by fractional distillation at a higher temperature than phenol. Among its derivatives are creolin, lysol, and solveol.

Creosote is a mixture of phenols, especially guaiacol, $C_6H_4.OH.OCH_3$, and creosol, or wood-tar, $C_6H_3.CH_3.OH.OCH_3$, obtained from coal-tar. It is a yellow, oily liquid with smoky odor and burning taste, soluble in 150 H_2O and freely in other solvents, except glycerin; b. p., 205° to 215°; miscible with an equal volume of collodion. It is used chiefly as an intestinal antiseptic.

The official creosote is a distillate from beechwood-tar, which may contain as much as 25 per cent. creosote. Commercial creosote is used for preserving timber.

Identification of Creosote.—$FeCl_3$ gives a violet color, changing to green and brown.

Acetaldehyd yields a carmine solution. Pure guaiacol forms a green liquid with conc. H_2SO_4.

Creosote does not coagulate collodion, and is insoluble in glycerin. A splinter of pine does not turn blue when dipped in creosote, then HCl, as phenol does.

Resorcin, $C_6H_4(OH)_2$, appears in colorless crystals which have a sweet taste and are very soluble. It is formed by fusing resins with caustic alkalies. It is only slightly poisonous, and is used as a gastrointestinal antiseptic and in manufacturing dyes. $FeCl_3$ gives a blue or violet color with weak solutions.

Pyrocatechin (catechol) and hydroquinone are, respectively, ortho- and para- dihydroxy-benzene. The latter is used in photography as a reducing agent. Guaiacol is monomethyl catechol; its carbonate is prepared by saturating with NaHO and treating with $COCl_2$.

Pyrogallin [$C_6H_3(OH)_3$] appears in glistening, white, generally soluble needles, prepared by heating gallic acid to 200°, by which CO_2 is driven off. It is a good reducing agent, and is used as a developer (deoxidizing agent) in photography. It turns red with ferric, blue with ferrous, salts. It gives a brown color to the hair.

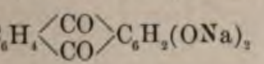
Experiment.—Show rapid oxidation (darkening) of pyrogallin with alcoholic solution of KHO when exposed to the air. For the same reason it furnishes a delicate test for traces of HNO_3.

Eugenol, $C_6H_3.C_3H_5.OCH_3.OH$, is a yellowish fluid contained in oil of cloves and other ethereal oils. It is the commercial source of vanillin.

Protocatechnic acid is $C_6H_3(OH)_2COOH$. Vanillin, the odoriferous principle of vanilla beans, is methylprotocatechnic aldehyd, and is prepared synthetically by several processes.

Phloroglucin, 1:3:5 $C_6H_3(OH)_3$, is obtained by fusing phenol with KOH. It is used with vanillin, dissolved in alcohol, to detect free HCl.

Anthraquinone, diphenylenediketone, occurs in yellow needles. On treating with H_2SO_4 and then soda and $KClO_3$, it yields alizarin or dihydroxyanthraquinone:—



$$C_6H_4\left\langle\begin{matrix}CO\\CO\end{matrix}\right\rangle C_6H_2(ONa)_2$$

This produces variously colored compounds with metallic oxids—turkey red with Al, blue with Ca, dark purple with ferric salts.

Alizarin monosodium sulphonate is a yellow reagent used for free acid in gastric juice. It turns violet by excess of caustic soda, through the formation of the disodium derivative.

Safrol, $C_6H_3.C_3H_5.O_2CH_2$, is found in oils of sassafras and camphor and other volatile oils. It is a colorless or faintly yellow liquid; sp. gr., 1.1.

Phenolphthalein, $C_{20}H_{14}O_4$, is prepared by dehydrating phthalic acid, $C_6H_4(COOH)_2$, by heating and then treating the anhydrid with phenol in presence of H_2SO_4, which removes another molecule of H_2O. It is a valuable indicator in alkalimetry.

The **naphtols** (α and β), $C_{10}H_7OH$, are similar to the phenols, being intestinal antiseptics derived from naphtalene. Beta-naphtol is used medicinally, as alpha-naphtol is poisonous. It appears in shining plates with carbolic odor and burning taste. It is readily soluble except in H_2O (1000 parts). Aqueous solutions are colored green by $FeCl_3$. Sodium naphtol (microcidin), $C_{10}H_7.ONa$, is used in aqueous solutions as a disinfectant for cleansing dental instruments.

Lustgarten's Test for β-Naphtol.—Evaporate material extracted with alcohol, and warm residue with KOH and $CHCl_3$, getting a blue color.

NITRO-DERIVATIVES.

Nitrobenzene (mirbane essence), $C_6H_5NO_2$, is a yellow oily compound, formed by nitration of benzene. It has the odor of bitter almonds and is used to flavor confectionery and perfumery, liqueurs and soaps. It is the source of anilin and coal-tar dyes, and is used in liquid shoe blacking.

Picric or carbazotic acid (trinitrophenol), $C_6H_2(NO_2)_3OH$, is prepared by acting on phenol, silk, or wool with HNO_3. It ppts. alkaloids and albumin, and is used as a yellow dye (for wool; dilute alkalies decolorize) and in explosives (lyddite, melenite, emmensite).

Test.—On warming an alkaline solution of picrate with conc. KCN,, blood-red potassium isopurpurate is formed.

Metadinitrobenzene, $C_6H_4(NO_2)_2$, is used in the manufacture of roburite, rifleite, and other explosives.

Nitro-compounds generally give a purple-red color on treating with brucin or anilin and a drop of H_2SO_4.

THIO-COMPOUNDS.

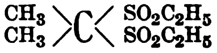
Sulphocarbolic acid, $HSO_3.C_6H_4OH$ (phenol-sulphonic, or sozolic, acid), is formed by dissolving phenol in strong H_2SO_4. Na and Zn sulphocarbolates are white soluble salts used as intestinal antiseptics. Eosolates are salts (Ag, Ca and quinin) of the sulphonic acid derivatives of the aliphatic creosote esters.

Ichthyol (Na or NH_4, ichthyo-sulphonate), $C_{26}H_{36}S_3Na_2O_6$, is a brown, tarry, strong-smelling liquid, obtained by dry distillation of a bitumen found in Tyrol. It contains about 10 per cent. of assimilable S.

Mercaptans (so called from their affinity for HgO), or hydrosulphids, are alcohols in which S has replaced O. They are liquids, insoluble in H_2O, inflammable, and with an unpleasant odor like leeks. They may be formed by treating haloid ethers with KSH:—

$$C_2H_5Cl + KSH = KCl + C_2H_5SH \text{ (ethyl mercaptan)}$$

Combined with oxids they yield mercaptids; with aldehyds, mercaptals; with ketones, mercaptols. The oxidation of mercaptans yields sulphonic acids; of mercaptols, sulphonals. The hypnotic, sulphonal

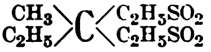


$$\begin{matrix} CH_3 \\ CH_3 \end{matrix} \!\!>\! C \!<\!\! \begin{matrix} SO_2C_2H_5 \\ SO_2C_2H_5 \end{matrix}$$

(diethyl-sulphon-dimethyl-methane) is formed by the reaction between acetone, ethyl mercaptan, and $KMnO_4$. It is a colorless, tasteless, odorless, crystalline substance, soluble in hot water.

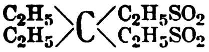
Experiment.—On melting sulphonmethane (sulphonal) with KCN, the offensive odor of mercaptan is perceived, and there is formed KSCN, which in solution gives a blood-red color with $FeCl_3$.

Trional, another hypnotic, is diethyl-sulphon-methyl-ethyl-methane:—



$$\begin{matrix}CH_3\\C_2H_5\end{matrix}>C<\begin{matrix}C_2H_5SO_2\\C_2H_5SO_2\end{matrix}$$

and tetronal is diethyl-sulphon-diethyl-methane:—



$$\begin{matrix}C_2H_5\\C_2H_5\end{matrix}>C<\begin{matrix}C_2H_5SO_2\\C_2H_5SO_2\end{matrix}$$

These are soluble in boiling water, alcohol, and ether.

Allyl sulphid ("garlic oil"), $(C_3H_5)_2S$, is the most important thio-ether. It is obtained from garlic-leaves and the seeds of many cruciferæ.

AMIDO-PHENOLS.

These are formed by reduction of the corresponding nitrophenols. The ethyl ethers of para-amido-phenol, $C_6H_4.OH.NH_2$, are termed phenetidins. From para-phenetidin, $C_6H_4.OC_2H_5.NH_2$, phenacetin (acetparaphenetidin), $C_6H_4.OC_2H_5.NHC_2H_3O$, is formed by treating with glacial acetic acid. It is a crystalline substance, soluble in alcohol, and is one of the best and safest of the coal-tar remedies. Phenocoll, or glycocoll phenetidin, has the formula $C_6H_4.OC_2H_5.NH.COCH_2NH_2$. Methacetin, or para-acetanisidin $= C_6H_4.OCH_3.NH.C_2H_3O$.

COMPOUND AMMONIAS.

Amins are alkyl substitutes of NH_3. They are primary, secondary, and tertiary, according as 1, 2, or 3 atoms of H are replaced. They are mon-, di-, or tri- when 1, 2, or 3 molecules of NH_3 are represented. They contain no O. They are characterized by a strong, disagreeable odor, often like dead fish. With HNO_2 primary amins yield corresponding alcohols. Amins also combine with acids to form salts.

All primary amins when warmed with chloroform and KOH, quickly form very offensive carbylamins or isonitrils. Imins are secondary amins containing the radical NH (imidogen). Hydramins are produced by introducing amido (NH_2) groups into alcohols of the olefin series.

The three methyl monamins [CH_3NH_2, $(CH_3)_2NH$, and $(CH_3)_3N$] are found in herring brine and many other decomposing products. The first is a combustible gas; the others, liquids. Propylamin is used as a nervous sedative.

Glucosamin, $C_6H_{11}O_5NH_2$, has been isolated from nearly all albuminous bodies.

Hydroxylamin, NH_2OH, made by the action of nascent H on HNO_3, is known only in solution. The protamins, or histon bases, lysin (a-e-diamidocaproic acid), arginin and histidin (a-amidocarbonic acid) form the essential nucleus of the protoplasmic molecule. They react pink to the biuret test.

Diethylen-diamin $[(C_2H_4)_2(NH)_2]$, or piperazin, appears in rhombic plates, readily soluble. It is used as a solvent for uric acid and gouty concretions.

Urotropin, hexamethylen-tetramin, is a crystalline substance soluble in water, used as a genitourinary antiseptic.

Saccharin (anhydro-ortho-sulphamin-benzoic acid), C_6H_4-$COSO_2NH$, is a coal-tar product, from toluol, 280 times as sweet as cane-sugar. It is soluble in alcohol and ether, and may be detected by this fact. The corresponding para compound is tasteless. Dulcin and sucramin are coal-tar derivatives similar to saccharin, and used to sweeten beer, syrups, jams, pastry, chocolates, champagne and other drinks.

Found in the cadaver are the diamins *putrescin* and *cadaverin*. *Isoamylamin* is a very poisonous ptomain sometimes present in decomposing yeast and cod-liver oil.

Cacodyl, or diarsenic tetramethyl $[As_2(CH_3)_4]$, is a colorless, very poisonous liquid with an extremely offensive odor. It takes fire on exposure to air. Cacodyl oxid $[As_2(CH_3)_4O]$ is formed by dry distillation of a mixture of As_2O_3 and KC_2-H_3O_2. It is a poisonous, oily liquid which, when oxidized with HgO, yields cacodylic acid $[(CH_3)_2AsO.OH]$, an odorless, crystalline substance, non-poisonous, and recently used in medicine in the form of its salts, best given intravenously. Cyanid of cacodyl is a white powder which, on exposure to air, gives off a very poisonous vapor.

Amids consist of an acid radical with the group amidogen, NH_2. They result when NH_2 replaces OH in acids. They contain C, N, O, and H. Imids have the group NH instead of NH_2. Alkalamids are formed by replacing 2H of NH_3 with an acid and an alkyl radical; as $NH.C_2H_5.CH_3CO$.

Acetamid, $C_2H_3O.NH_2$, is prepared simply by heating $NH_4C_2H_3O_2$, driving off H_2O. It appears in soluble crystals with a mousy odor.

Carbamid, or urea $[(NH_2)_2CO]$, was about the first organic compound prepared synthetically, by heating its isomer: NH_4CNO. It is the chief solid constituent of urine. It is related to H_2CO_3 through the intermediate body carbamic acid, NH_3CO_2. It combines with certain acids, forming ureids and setting free H_2O.

Formamid, $NCHO.H_2$, is a colorless liquid which combines with chloral to form the soluble crystalline hypnotic chloralamid.

Phenylamin, or anilin, $NH_2C_6H_5$, is a colorless, oily liquid, b. p. 180°, nearly insoluble in H_2O. It is prepared by treating C_6H_6 with HNO_3 and nascent H (Fe and HCl). It combines directly (without substitution) with acids. It is a narcotic poison, and is the basis of the anilin dyes (not poisonous), which are made by oxidation processes. Bleaching powder and anilin give a purple dye; $K_2Cr_2O_7$, H_2SO_4, and anilin, blue:—

$NH_2C_6H_5 + 2C_7H_9N$ (toluidin) $+ 3O = C_{20}H_{19}N_3$ (rosanilin) $+ 3H_2O$.

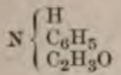
Experiment.—Make rosanilin hydrochlorate by warming 2 gm. of $HgCl_2$ and 3 or 4 drops of anilin until the color becomes green and then purple. Let cool and add a few drops of alcohol and a drop or two of HCl. Then stir into beaker of H_2O.

Diamidobenzol, $C_6H_4(NH_2)_2$, is a whitish crystalline powder, with strongly basic properties. It gives an intense yellow color with even traces of nitrous acid.

Sulphanilic acid, $C_6H_4.NH_2.SO_3H$, is a colorless crystalline substance obtained by heating anilin with H_2SO_4.

Anilids are derivatives of anilin obtained by replacing ammonia or amido H by acid radicals. If H is replaced by an alkyl radical, the derivative is known as an alkylanilin; as methylanilin, $C_6H_5.NH.CH_3$.

Acetanilid, or phenyl acetamid,



$$N\begin{cases}H\\C_6H_5\\C_2H_3O\end{cases}$$

is prepared by boiling anilin with glacial acetic acid. It appears in white, unctuous crystals, sparingly soluble in H_2O, more freely in alcohol. On warming with HCl it is decomposed into anilin and acetic acid.

Experiment.—Prove presence of anilin in acetanilid by heating together a mixture of equal parts of acetanilid and powdered NaHO. After a few minutes invert test tube and allow oily globules of anilin to run out, keeping up the warming process.

Identification of Acetanilid.—Boil 0.1 gm. with 1 c.c. of HCl and then add 1 c.c. each of 5 per cent. phenol solution and saturated solution of bleaching powder. A cloudy, red mixture is formed, which turns dark blue on supersaturating with NH_4HO.

Amido-acids are acids in which 1 atom of H has been replaced by NH_2. They possess both acid and basic properties. Amidoacetic acid (glycin, glycocoll) has the formula $CH_2.NH_2.COOH$. It is present in most proteins, especially collagens, and has a sweet taste. Amidoformic, or carbamic, acid, $NH_2.COOH$, is present as a salt in ordinary ammonium carbonate. It is formed by direct union of CO_2 and NH_3,—$C.NH_4.NH_2O_2$.

Leucin is amidocaproic acid: $C_5H_{10}.NH_2.COOH$. Like its congener, tyrosin, it is a product of albuminous decomposition in the intestines. Aspartic is identic with amidosuccinic acid, $CH_2.CH(NH_2).(COOH)_2$. Amic or amidic acids, or alanins, are formed by replacing the HO of acids by the amido-group; *e.g.*, lactamic acid, $CH_3.CH.NH_2.COOH$. Compounds derived from the type NH_4 have the termination "onium"; thus, AsH_4, arsonium.

PYRIDINS.

These tertiary monamins are colorless liquids, insoluble in water, but soluble in alcohol, ether, and fixed oils. Pyridin, C_5H_5N, is present in bone-oil, coal-tar naphtha, and tobacco-smoke. It has a sharp, characteristic odor. Pyrrol, C_4H_5N, is also in coal-tar and bone-oil. Iodol, C_4I_4NH, is a light-brown, odorless, tasteless powder containing 89 per cent. I. It is derived from pyrrol by treating with I in presence of oxidizing agents. It is used as a substitute for CHI_3, and is not toxic.

Quinolin, or chinolin, C_9H_7N, is prepared by distilling quinin or cinchonin with potash. It corresponds with naphtalin in which one CH group is replaced by N.

Kairin, $C_{10}H_{13}.NO.HCl$, is the hydrochlorid of methyl-oxy-chinolin-hydrid. It appears in white crystals soluble in 6 H_2O or 20 alcohol.

Thallin, $C_{10}H_{11}NO$, or tetra-hydro-paramethyl-oxyquinolin, is a white, aromatic, crystalline substance, generally soluble. It is colored a bright green by $FeCl_3$ and other oxidizing agents.

Piperin is the active principle in both black and white pepper. It has the same empiric formula as morphin, but is not an alkaloid. It contains a benzene and a pyridin ring.

AZO AND DIAZO COMPOUNDS.

The group $-N=N-$ links an alkyl to an acid radical in diazo; two alkyl radicals in azo compounds. These compounds are colorless, crystalline substances, soluble in water, and are formed by treating aromatic amins with HNO_2. From azo-benzene, $C_6H_5-N=N-C_6H_5$, the beautiful azo dyes are derived. When an atom of O is inserted between the N atoms, an azoxy compound is formed.

HYDRAZINS.

These are derivatives of hydrazin, or diamin, NH_2-NH_2, a colorless, stable, alkaline gas, and are formed by replacing H with alkyl radicals.

Phenyl-hydrazin, $C_6H_5-NH-NH_2$, prepared by reduction of diazo-benzene, is a colorless, oily liquid, soluble in alcohol and ether, and a powerful reducing agent, forming characteristic crystalline compounds called osazones with various sugars, and hydrazones with aldehyds.

Antipyrin, or phenazone (phenyl-dimethyl-pyrazolon), $C_{11}H_{12}N_2O$, is derived from phenyl-hydrazin by heating with diacetic ether $[(C_2H_3O_2)_2C_2H_5O]$, forming phenyl-methyl-pyrazolon, which is then made to take up another methyl group in place of H. Antipyrin appears in white crystals, very soluble in H_2O and other solvents.

According to Sajous, antipyrin and other synthetic analgesics act by exciting the sympathetic center in the pituitary body, thereby causing excessive constriction of the arterioles; the volume of blood circulating about the sensory terminals of the diseased area being reduced, the pain ceases. Except antipyrin, all modern antipyretics (phenetidin compounds) owe their action as such to the formation of simple derivatives of paramidophenol in the tissues. This decomposition should be gradual, as otherwise there result collapse and destructive blood changes (methemoglobinemia). The cyanosis is due to vasoconstriction and consequent engorgement of capillaries and slowing of the current therein, whereby oxyhemoglobin is unduly reduced. (SAJOUS.)

Identification of Antipyrin.—$FeCl_3$ gives deep red; HNO_2 yellow, then intense red on warming; KNO_2 and $HC_2H_3O_2$ (a few drops of each) give an intense-green color.

NITRILS AND CARBYLAMINS.

These are isomeric compounds of organic radicals with CN. Nitrils, or cyanids, have the general formula $R - C \equiv N$; carbylamins, or isocyanids, $R - N \equiv C$. The nitrils are volatile liquids or solids, yielding organic acids when heated with H_2O in presence of mineral acids or alkalies: *e.g.*, $CH_3CN + 2H_2O = CH_3.COOH + NH_3$. Hence they correspond with acid oxids or anhydrids. They may be formed by heating alkyl iodids with KCN.

Fulminic acid, $C_2N_2H_2O_2$, is very unstable. Mercuric fulminate is made by adding alcohol to a solution of Hg in HNO_3, and is used as an explosive in percussion-caps, developing a pressure of 43,000 atmospheres by detonating in its own volume.

The carbylamins are marked by a disgusting odor and are formed by heating hydrocarbon iodids with AgCN. When heated with H_2O and mineral acids they form amins and organic acids: *e.g.*,

$$CH_3NC + 2H_2O = CH_3NH_2 + HCOOH$$

The **isosulphocyanates**, or mustard-oils, RNCS, break down into an amin, H_2S, and CO_2 on treating with H_2O and alkalies. The most important member of this group is allyl sulphocyanate, C_3H_5NCS, found in fermenting mustard-seed, and horseradish. Cyanogen compounds are often present in furnace and volcanic gases.

ALKALOIDS.

Alkaloids are physiologically active vegetable (or animal) nitrogenous principles, or natural organic bases (tertiary aromatic heterocyclic—contain, as a rule, one ring having a N atom in nucleus), derived from pyridin (C_5H_5N), chinolin (C_9H_7N), and isochinolin. The liquid and volatile alkaloids are amins; the solid non-volatile, amids (these contain O). The latter is much the larger class. Their names all end in *in* (or *ine*), English; *ina,* Latin. The vegetable alkaloids exist in combination with tannic, malic, meconic, $H_3C_7HO_7$ (opium), kinic (cinchona), and other acids. They are extracted from the comminuted plants by dissolving out in H_2O or alcohol, or by treating with dilute acids, then with CaO or MgO, and then dissolving in alcohol, ether, chloroform, or dilute acids. The concentrated aqueous solution, to which the alkaline precipitant has been added, may be rotated together with chloroform in a separatory funnel. The chloroform, with the dissolved alkaloids, is run off from below and evaporated. This is the so-called shaking-out process.

Alkaloids are generally white, bitter, and insoluble in H_2O, but soluble in other solvents. Morphin is insoluble in ether. Their salts are formed by direct addition of the acid; they are neutral to litmus, and are more soluble in water and in alcohol; hence are employed in medicine rather than the simple alkaloid. With a few exceptions, they are insoluble in ether and chloroform.

Alkaloids and alkaloidal salts are incompatible with their reagent and with bases, carbonates, and bicarbonates. Many of them are poisonous. The chemic antidote for all is tannin or well-diluted $KMnO_4$ (grain for grain of poison).

Test Precipitants.—1. Tannic acid: Resulting tannates are difficultly soluble in cold water, but soluble in alcohol or excess of tannic or other acids.

2. Haloid salts of Hg: Double nearly insoluble salts. Mayer's solution [$HgI_2(KI)_2$] consists of 13½ gm. of $HgCl_2$ and 50 gm. KI in 1000 c.c. of H_2O. It ppts. all the alkaloids in acidulous solutions in absence of alcohol or acetic acid.

3. Picric acid: Cinchona bases especially.

4. Phosphomolybdic and phosphotungstic acids: Ppt. great majority of alkaloids.

5. Potassium chromate and dichromate: Ppt. concentrated aqueous solutions as chromates.

6. Chlorids of Au and Pt: Crystalline double salts, with many alkaloids.

7. Wagner's Reagent is I (1), KI (2), H_2O (100). Used in excess in acid non-alcoholic solutions, it ppts. dark brown to black periodids, soluble in $Na_2S_2O_3$ by reduction to hydriodids.

Color-reactions.—Dehydration: H_2SO_4, $ZnCl_2$, P_2O_5.

Oxidation. HNO_3, Cl, Br, NaClO; H_2SO_4 and $KClO_3$ or $KMnO_4$, chromic, molybdic, iodic, and tungstic acids.

Cocain and pilocarpin reduce calomel on rubbing together with a glass rod.

In testing for alkaloids Witthaus advises to place a drop of the liquid under examination and one of the reagent near each other on a strip of black glass, and bring the two together with a pointed glass rod.

VOLATILE ALKALOIDS.

These are colorless, oily liquids, and turn brown on exposure to the air. They are capable of distillation unchanged. Coniin, or cicutin, was the first vegetable alkaloid formed synthetically in the laboratory. Coniin is marked by a repulsive odor, and is obtained from hemlock-fruit. It acts as a motor paralyzant poison. Nicotin, $C_{10}H_{14}N_2$, is the poisonous principle of tobacco, in which it is present to the extent of 1 to 7 per cent. of dry leaf, in combination with malic and citric acids. It is soluble in water. It acquires a peculiar strong odor on standing. When tobacco is smoked the nicotin is converted largely into pyridin. Nicotin is a narcotic poison, and 1 m. has proved fatal.

Identification of Coniin.—Strong HCl gives a red coloration.

Identification of Nicotin.—Violet with HCl; orange with HNO_3. HCOH and HNO_3 give a vivid rose-red color. Coniin and nicotin are particularly liable to be simulated by putrefactive products.

Lobelin, from lobelia, or Indian tobacco, has an odor like tobacco mixed with honey. Spartein, $C_{15}H_{26}N_2$, from the leaves and branches of broom, is an odorless, very bitter cardiac tonic. Spartein is very uncertain in action, partly perhaps because of its volatility.

Spigelin, from spigelia, or pinkroot, is used as a vermifuge for roundworms. Pelletierin, or punicin, is a liquid alkaloid in pomegranate root-bark. It is a nearly specific anthelmintic for tapeworms.

NON-VOLATILE ALKALOIDS.

Solanaceæ.—These are closely allied mydriatics and deliriants. They quicken the pulse and respiration, and may cause death by overstimulation, leading to paralysis. The most potent and important is atropin, from *Atropa belladonna*. Its sulphate is commonly employed. Henbane has two important alkaloids, hyoscin and hyoscyamin. Daturin is a mixture of atropin and hyoscyamin. Duboisin, from the leaf of an Australian tree, strongly resembles atropin.

The solanaceous alkaloids consist of the base tropin or oscin (scopolin) combined with aromatic (chiefly tropeic) acids, which are substituted for an H of the HO in the base. These ester-like tropin combinations are called tropeins; those of oscin, osceins.

Atropin and hyoscyamin, $C_{17}H_{23}NO_3$, are isomeric, the former being optically inactive, the latter levorotatory. Atroscin and scopolamin, $C_{17}H_{21}NO_4$, are isomeric osceins; the former is inactive, the latter levogyrous. A mixture of the two alkaloids forms commercial hyoscin. Homatropin (a synthetic) is oxytoluic acid tropin.

Vitali's Test for Atropin.—Barely moisten dry residue from conc. solution on white porcelain with H_2SO_4 on point of narrow glass rod, add about 1 mg. $NaNO_2$ and rub into spot, which is then touched with freshly prepared saturated solution of KOH in absolute alcohol, added in excess of acid. Tropein reaction (shows 1/8000 grain) is a fine violet color, quickly fading to dark red and disappearing.

Physiologic Test.—One two-thousandth grain of atropin in a drop of solvent shows dilation of the pupil when dropped in the eye in about one-half hour.

Cinchona Group.—Peruvian bark contains at least 5 per cent. of alkaloids, of which one-half should be quinin. Of the 43 cinchona alkaloids, the chief four are quinin ($C_{20}H_{24}N_2O_2$), quinidin, cinchonin, and cinchonidin. These are all effective febrifuges and antiperiodics. The principal salts of quinin are the sulphate, bisulphate, hydrobromate, hydrochlorate, and valerianate. The neutral sulphate is soluble in 740 H_2O or 65 alcohol. The hydrochlorate is most soluble: in 34 of water. The cumulative effects of quinin are due to rapid absorption (fifteen minutes) and slow elimination (two or three days). Quinidin is isomeric with quinin.

Identification of Quinin.—Solutions in excess of dilute H_2SO_4 show a strong fluorescence. This is also noted with quinidin.

To 10 c.c. solution of quinin add 2 m. of Br water and excess of NH_4HO, and get emerald green of thalleioquin. Quinidin gives the same reaction, but, unlike quinin, is pptd. from neutral solutions with KI.

Herapathit Test.—Dissolve ½ gm. of alkaloid in 15 c.c. of alcohol of 0.83 sp. gr., dilute with 5 c.c. of water, and acidulate fluid with 2 c.c. of 10-per-cent. H_2SO_4; add to this solution of 0.2 gm. of I in 10 c.c. of alcohol (0.83 sp. gr.); warm mixture slightly and allow to cool. Note the quite insoluble microcrystalline ppt.: dark green = quinin; red = quinidin; yellow = cinchonidin; no ppt. = cinchonin.

Opium, or Thebaicum, Group.—Of the seventeen alkaloids (in combination with meconic and lactic acids) and extracted from poppy, morphin, $C_{17}H_{19}NO_3$ (10 to 14 per cent.), is chief. Narcotin, a tetanizer, constitutes 4 per cent.; papaverin, a narcotic, ½ to 1 per cent.; codein, an analgesic, 0.2 to 0.8 per cent.; narcein, a hypnotic, 0.02 per cent.; and thebain, a tetanic convulsant, 0.2 to 0.5 per cent. Narcotin and narcein are isomeric. Opium may be deodorized with ether, which dissolves out narcotin. The sulphate is the common salt of morphin. It dissolves in 24 H_2O, 702 alcohol. The hydrochlorate of morphin on heating with HCl *in vacuo* is dehydrated into the emetic, apomorphin hydrochlorate, $C_{17}H_{17}NO_2.HCl$. Solutions of this on exposure to air turn green. Other artificial derivatives are heroin (diacetyl-morphin), dionin (hydrochlorid of monoethyl-ester of morphin), and peronin (hydrochlorid of benzyl ether of morphin). Codein (morphin methyl-ester) is made synthetically by heating morphin with CH_3I.

Most opium alkaloids (except morphin and narcotin) are said (Kobert) to originate by fermentation in the exuded juice of the poppy capsule while drying. There is no opium in poppy petals. Morphin is excreted mainly by the digestive tract, only traces being found in the urine; therefore it is not contraindicated in uremic convulsions.

Identification of Morphin.—HNO_3 gives a red color, fading to yellow and discharged by reducing agents. $FeCl_3$ (very dilute) colors blue, turning green, and disappearing on heating.

Fröhde's reagent (solution of molybdic acid in H_2SO_4) added to a crystal of morphin gives a violet color, turning blue, dirty green, and faintly pink.

Identification of Codein.—This shows a claret-red color with Br water on shaking and adding NH_4HO.

Identification of Apomorphin.—HNO_3 gives a blood-red color; aqueous solution treated with a few drops of Na_2CO_3 and one drop alcoholic I, gives emerald, turning violet on shaking with ether.

Selenious acid (0.5) in H_2SO_4 (100) gives, with morphin, an evanescent blue, then intense blue-green to persistent olive-green; with apomorphin, dark blue-violet; with codein, blue, quickly changing to emerald and then persistent olive; with narcein, faint greenish-yellow, then violet; with narcotin, greenish steel-blue, later cherry-red.

Test for Morphin in Opium Solutions.—On acidulating with $HC_2H_3O_2$ and then adding $Pb(C_2H_3O_2)_2$, lead meconate is pptd. and morphin remains in solution, to be tested in the filtrate as described above.

Strychnos Alkaloids.—Strychnin and brucin are found in the seeds of *S. nux vomica* and *S. ignatia* and in *S. tiente*, the deadly upas-tree root-bark of Java, used as an arrow-poison. Strychnin is obtained mostly from ignatia. Strychnin is so bitter as to be perceptible in a dilution of 1 to 700,000. It is comparatively stable. Its usual salt is the sulphate. It produces death by asphyxia from tetany of the respiratory muscles. Brucin ($C_{23}H_{26}N_2O_4$), or dimethoxystrychnin, is similar, but milder in action.

Identification of Strychnin.—H_2SO_4 and a small crystal of $K_2Cr_2O_7$ give blue, running through a rainbow of colors (blue, violet, purple, pink, red) to red-yellow. This test is said to have detected as little as 1/100000000 grain of strychnin. A mixture of morphin and hydrastin gives a similar reaction, as does likewise quebrachin. Chloroform is the best agent to extract strychnin from the stomach contents.

Identification of Brucin.—It turns blood-red with HNO_3, yellow on heating, violet on adding $Na_2S_2O_3$.

Ptomains (pellagrocein in decomposed cornmeal) may give chemic reactions similar to those of strychnin, and also cause tetanic symptoms.

Much morphin or much brucin, sugar and more than traces of tissue-substance prevent the fading purple action of strychnin. Purify dry residue, after the usual process of alkaline extraction, by moistening with 2 or 3 drops of H_2SO_4, and heating on water-bath for an hour or two. Stir blackened residue with H_2O, filter, wash, make faintly alkaline and shake out with chloroform. Evaporate on porcelain and make usual chemic tests. The hot H_2SO_4 removes hydrastin as well. To test for strychnin in presence of brucin, treat residue with conc. H_2SO_4, then with very little HNO_3, and after the red color has faded to yellow, add a minute fragment of $KMnO_4$ or $K_2Cr_2O_7$. A fading purple shows strychnin.

Physostigmin, or Eserin.—This myotic ($C_{15}H_{21}N_3O_2$) is extracted from Calabar bean. The chief salts are the salicylate and sulphate. It produces death in the same way as strychnin.

Cocain.—This alkaloid is found in the leaves (0.15 to 0.65 per cent.) of erythroxylon coca, a South American shrub. Coca leaves contain also the alkaloids ecgonin, benzoyl ecgonin, and hygrin (oily). The hydrochlorate ($C_{17}H_{21}NO_4.HCl$) is readily and generally soluble. It is a local anesthetic. Less than a grain has produced death by respiratory paralysis or tetanic spasm of the heart. Eucain is a valuable and less toxic derivative; β-eucain is less irritant than α-eucain. Cocain is a general protoplasm poison (causes scars aside from infection). Its anesthesiophore function is due to the benzoyl group.

Identification of Cocain.—The powdered drug mixed with calomel turns gray or black on moistening with the breath. On adding 5 per cent. CrO_3 to a solution of a cocain salt, a yellow ppt. is formed, dissolving at once, but rendered permanent by the addition of conc. HCl.

Pilocarpin.—This is a valuable sudorific extracted from jaborandi leaves. The nitrate and hydrochlorate are the salts in use. Jaborin from the same source is less important. Pilocarpidin is an oxidation product.

Aconitin. — This alkaloid is present in monk's-hood or wolf's-bane along with the more powerful pseudaconitin and japaconitin. It is a combination of the base aconin with benzoic acid. One-twelfth grain has caused death by paralysis of heart and respiration. Crystalline aconitin (or hyoscyamin) is four times as strong as the amorphous. Aconitin on standing or on boiling changes into bitter amorphous alkaloids (aconin), which are only slightly toxic. Napellin is a narcotic alkaloid present in aconite.

Identification of Aconitin.—KI gives a reddish-brown amorphous ppt. The physiologic tests are most delicate and important.

Veratrin.—Veratrum (poke-root, hellebore) contains jervin, cevadin, pseudojervin, protoveratrin. The veratrin of the U. S. P. is a mixture of alkaloids (chiefly cevadin) from cevadilla seeds.

Identification of Veratrin.—H_2SO_4 gives a yellow color, turning scarlet and violet-red.

Hydrastis Group.—The yellow alkaloid berberin (a simple bitter) is present in barberry, columbo, golden seal, mandrake, pareira brava, yellow parilla, prickly ash, and other plants. Hydrastin is the white alkaloid of hydrastis; it oxidizes to yellow needles of hydrastinin. These three alkaloids are astringent and antiseptic.

Identification of Hydrastis Alkaloids.—Berberin dissolved in dilute HCl and Br water added, gives a blood-red color. Hydrastin dissolved in dilute H_2SO_4, with a few drops of $KMnO_4$ added, shows blue fluorescence (formation of hydrastinin). To 1 per cent. aqueous solution of hydrastinin add excess of Br water, getting a yellow ppt.; the addition of NH_4OH dissolves this to a nearly colorless solution (hydrastin gives a brick-red ppt.).

The ipecac alkaloids are emetin and cephalin. Theobromin is present in cacao-seeds (up to 4 per cent.) and kola-nuts. Caffein, thein or guaranin (methyl-theobromin) is the active principle of tea (2 to 4.5 per cent.), coffee (1.2 per cent.), maté (0.2 to 2 per cent.), guarana (5 per cent.), and kola-nut. Theophyllin (in tea) is 3 : 7 dimethylxanthin. Caffein (thein, guaranin) is 1 : 3 : 7 trimethylxanthin. Citrated caffein contains 50 per cent. caffein, and is a white, acid powder.

Identification of Caffein.—A 5 per cent. solution of K_4FeCy_6 heated with half its volume of HNO_3 and then diluted with water, gives a ppt. of Prussian blue. Caffein also reacts to the murexid test (see "Uric Acid").

Aspidospermin is found in quebracho. Gelsemium contains the alkaloids gelsemin (crystalline) and gelseminin (amorphous, toxic). The strophanthin of commerce (mostly pseudostrophanthin) is often a very toxic and variable mixture. The convulsive alkaloid cornutin is the chief factor in the action of ergot on the uterus (Kobert). The *Anhalonium Lewinii*, a member of the cactus family, contains an hypnotic alkaloid, pellotin, and an intoxicating alkaloid called mezcalin.

From chelidonium are obtained chelerythrin (sanguinarin), chelidonin, chelidoxanthin, and berberin. Sanguinaria contains sanguinarin (white; red salts), chelerythrin, protopin, and berberin; serpentaria, the bitter aristolochin; spigelia, the anthelmintic spigelin; menispermum, berberin and menispin. Uva ursi contains arbutin (urinary antiseptic), ericolin and ursone. Colchicum has two active principles: a crystalline, colchicein, and a non-crystalline, colchicin. The alkaloids of staphisagria include the very poisonous delphinin, with delphinoidin and delphisin. Other unimportant vegetable alkaloids are buxin (pareira root), erythrophlein (casca), avenin (oats), agrostemmin (poisonous alkaloid in cereal, Agrostemma githago), columbin (calumba), betain (raw beet-sugar), canadin (hydrastis), oleandrin and the alkaloids of hops.

ANIMAL ALKALOIDS.

Ptomains are products of putrefaction of albuminous substances in dead or living bodies. Amido-, azo-, and diazo- groups are most common. Like vegetable alkaloids, they are solid or liquid, fixed or volatile, amorphous or crystalline, bitter or tasteless. Their odor may be wanting, or sweet and aromatic, or cadaveric. In chemic reactions they correspond closely to vegetable alkaloids, for which they may be mistaken. They differ from most vegetable alkaloids in being optically inactive. They are temporary and transitory in nature. Those formed in the presence of little O are toxic. Precipitation by general reagents of extracted body tissues is not conclusive of the presence of vegetable alkaloids. To distinguish vegetable alkaloids from ptomains, get the former into crystals by repeated purification. Many ptomains differ from true alkaloids in constitution, having their N in an open-chain (acyclic) molecule, and are classed under amins.

The methylamins and ethylamins are not poisonous. The following are all toxic: Putrescin and cadaverin, in corpses; tyrotoxicon, $C_6H_5N_2$, in putrid cheese, milk, and cream (ice-cream, cream-puffs); muscarin, in decomposed flesh, fish, and fungi; mytilotoxin, $C_6H_{15}NO_2$, in oysters and other mussels; neurin, in decomposing meat; and cholin, in animal tissues, hops, and ergot. Cholin, $N(CH_3)_3.C_2H_5O.OH$, is converted by oxidation into muscarin, and by dehydration into neurin.

Leucomains are formed in the living body by retrograde metamorphosis with insufficient O. They are much increased in anemia, chlorosis, and constipation. They are mostly nontoxic. Leucomains comprise purin bases and creatins.

Toxins are poisonous bases or albumins, the products of specific bacteria and the direct cause of most infectious diseases. Toxins are soluble in water, dialyzable but uncrystallizable, and resemble albumoses. They are pptd. by conc. alcohol or $(NH_4)_2SO_4$. Heat eliminates or destroys their toxicity, and they are readily split into prototoxins, deuterotoxins and tritotoxins, which differ in their avidity for antitoxin. Tetanus and diphtheria toxins are extracellular; most others are intracellular, being set free only on breaking down of the containing germs. The soluble products of bacteria are freed from the figurate elements by passing through porcelain filters.

Diphtheria poison is a white, amorphous toxalbumin. The typhoid bacillus produces typhotoxin, $C_2H_{17}NO_2$. The tetanus bacillus produces two toxins, tetanin and spasmotoxin, both of which excite tonic and clonic convulsions in an advanced stage of the disease, through their action on the motor ganglion cells. Crotin is a toxalbumin in Croton tiglium, not in croton-oil; ricin, in castor beans, not in the oil.

Soluble antitoxins of unknown composition are set free from the white blood-cells and the fixed tissues. They antagonize the toxins specifically, and account for artificial immunity. They are usually preserved in phials, hermetically sealed in the blowpipe flame, by the addition of 0.5 per cent. trikresol (mixture of ortho-, para-, and meta-), $C_6H_4CH_3OH$, which is non-irritant and slightly anesthetic; they may also be had in the dry, solid form, which keeps indefinitely. Bactericidal sera (antipneumococcus, antistreptococcus) in their nature cannot be expected to yield such brilliant results as the antitoxic sera. An antitoxic unit neutralizes enough toxin (when injected at the same time) to kill one hundred guinea-pigs. Very concentrated antitoxic serums are now in use (3000 units per c.c.). The antitoxin is present in the pseudoglobulin portion (soluble in salt solution).

PROTEINS.

Representatives of this group are essential parts of protoplasm and of animal and vegetable fluids. They are very complex substances of the cyclic series with hundreds or thousands of atoms in a molecule, chiefly C (50 to 55 per cent.), H (7 per cent.), O (20 to 24 per cent.), N (15 to 18 per cent.), and S (in most, ⅓ to 2½ per cent.): P and Fe in a few. The average composition is represented by the formula $C_{144}H_{224}N_{36}O_{44}S_2$. They yield NH_3, H_2S, fatty acids, amido-acids (leucin, tyrosin, glycocoll, aspartic acid, glutamic acid), histon bases (lysin, histidin, arginin), etc., on decomposition.

Plant proteins are derived from nitrates in the soil, which are reduced in the chlorophyl-bearing portions of the plant by formaldehyd to HCN, and this is probably the form in which N enters into the albuminous molecule. They are stored up as minute granules (sometimes crystalline) in seeds, roots, and tubers. Animals derive all their proteins from vegetable sources, and eventually break them down into simpler compounds.

Proteins are colorless, odorless, nearly tasteless substances, amorphous and non-dialyzable (except peptons) and levorotatory (some nucleoproteids are dextrorotatory). In pure solution proteins are neutral, but take on basic or acid characteristics in the presence of acids (2 molecules to 1 of protein) or salts. They easily putrefy, and are readily coagulated by heat, mineral acids, alcohol, and mineral salts. They are converted by digestive juices into acid or alkali albumins, then albumoses, and finally peptons. On heating dry they char and give forth the odor of burnt horn or wool. The classes of proteins and the chief members of each class are shown in the following table. It is a noteworthy fact that the same protein may exhibit different properties under varying conditions and in different parts of the body.

Protamins, $C_{30}H_{57}N_{17}O_6$, are thought to constitute the essential nucleus of protein molecules. Histons are more complex than protamins, are strongly basic, and contain no P or carbohydrate group. They occur in the spleen, thymus, and lymph glands.

Native Albumins.—Soluble in distilled water; coagulated by heat.	Serum-albumin—4 to 5 per cent. in human blood; used in dyeing, calico-printing, and refining cane-sugar. $C_{450}H_{720}N_{110}S_6O_{140}$. Cell-albumin. Muscle-albumin (myoalbumin). Milk-albumin (lactalbumin) — 0.75 per cent. in cows' milk; 1 per cent. in woman's milk. Egg-albumin — white of egg; pptd. by ether (serum-a., not) or by HCl (ppt. not soluble in excess as with serum-a.); used as a glaze and a vehicle for colors in calico-printing, for softening leather, and in book binding and photography. Plant-albumin—soft-growing vegetables; flocculi on heating plant-juices; leucosin in wheat, rye, barley. Paralbumin (pseudomucin) — found in fluid of ovarian cysts. Protones — intermediate tryptic digestion products of protamins. Keratins — horny parts: nails, hair, horns, nerve-sheaths, feathers; contain large amount of loosely united (cystin) S (4 or 5 per cent.): neurokeratin in neuroglia of nerves.
Globulins.—Insoluble in pure H_2O; soluble in dilute solutions of neutral salts (pptd. by excess); coagulated by heat; pptd. by current of CO_2, by diluting freely with H_2O or by removing salt by dialysis.	Serum-globulin (paraglobulin, fibrinoplastin)—2.2 per cent. of blood-plasma. Two fractions are: euglobulin (pptd. by dialysis), and pseudoglobulin (not pptd. by dialysis). Fibrinogen—pptd. by saturating with NaCl; changed to fibrin by f.-ferment. Myosinogen (muscle-plasma)—yellowish fluid clot after death (*rigor mortis*); extracted with 10 per cent. NH_4Cl, pptd. by excess of H_2O. Cell-globulin. Ovoglobulin. Lactoglobulin. Crystallin (globulin)—25 per cent. of crystalline lens. Globin—insoluble proteid, from spontaneous decomposition of hemoglobin. Plant-globulin — hemp, nuts, castor-bean, etc.; edestin (crystallizable) in cereals.
Derived Albumins (*Albuminates*). — Soluble (when freshly pptd.) in dilute acids and alkalies; pptd. by neutralizing or by strong mineral acids.	Acid albumins—slightly alkaline reaction; syntonin formed in stomach by HCl. Alkali albumins—slightly acid reaction; on adding $CaCO_3$ they dissolve in H_2O with effervescence. Plant-caseins, or legumin—in almonds, oats, lentils, pease, and beans (nearly 25 per cent.); insoluble in dilute alcohol.

Fibrins.—Slowly soluble in dilute acids or 10 per cent. NaCl.

- Fibrin—produced by clotting of blood, lymph, or chyle; elastic, gelatinous, fibrillar; decomposes H_2O_2.
- Gluten-proteins—soluble in dilute alcohol; best obtained by kneading wheat-flour on a sieve; starch passes through; sticky, elastic glutin remains. More gluten in wheat (8.6 per cent., composed about equally of glutenin and gliadin, or plant-gelatin) than in other grains.
- Zein is a fibrin-like proteid in maize.

Coagulated Proteids.—Dissolved difficultly by strong hot acids or alkalies; readily digested.

- Paracasein (tyrein)—produced by action of rennin on casein—milk-curds.
- Heat or Acid Products—boiled egg, for instance.

Albumoses (Proteoses, Propeptons).—All soluble in dilute NaCl, and some in H_2O; not coagulated by heat.

- Primary
  - Proto- (hemi-)—much tyrosin, tryptophan and monoamino-acids.
  - Hetero- (anti-)—much leucin, glycocoll and diamino-acids.
  - Gluco- contains carbohydrate group.
- Secondary—deuteroalbumose (hydrolyzed primary). Hirudin (in leeches) prevents coagulation of blood.
- Hemi- and anti- groups separated by 3 per cent. H_2SO_4, which throws down gelatinous mass of anti-albumid, insoluble in dilute acids, readily soluble in dilute Na_2CO_3.

Peptons.—Generally soluble, very hygroscopic, and quite diffusible; bitter taste; not coagulated by heat.

- Ampho-, anti- and hemi- groups not definite bodies.
- Peptids do not give biuret reaction.
- Antipeptons, on artificial tryptic digestion, yield protamins.
- Both peptons and albumoses may be produced by putrefaction.

Compound Proteins, or Proteids.—Yield on cleavage (boiling with dilute mineral acids) simple proteins and non-proteins.

- Glucoproteids, or metalbumins (acid, viscid, thready).
  - Mucin—cells of mucous membranes, saliva, tendons, umbilical cord; pptd. by $Pb(C_2H_3O_2)_2$, $HC_2H_3O_2$ (if neutral salts absent), or alum; soluble in dilute alkalies; swells in H_2O and dissolves in excess; cleaves into albumin and a carbohydrate reducing agent—no S.
  - Mucoids—connective tissue, cartilage, cornea, sclera, and ovarian liquids; similar cleavage products to mucin, but not pptd. by $HC_2H_3O_2$.
- Nucleins—chief component of cells; 5 per cent. P (as H_3PO_4) in combination with albumin or a nuclein base (adenin, guanin, xanthin, hypoxanthin); most contain Fe; readily soluble in dilute alkalies, not attacked by gastric juice. Pseudonucleins yield no xanthin bases.
- Nucleo-proteids (compounds of nucleinic acid with histons, protamins and other albumins)—gland-cells; viscid; acid reaction; soluble in H_2O; thrown out of solution by $HC_2H_3O_2$ or neutral salt solutions. Phosphocarnic acid is a gluconucleo-proteid in muscle.
- Nucleoalbumins (phosphoglobulins) include vitellin, casein, phytoglobulins, etc.; all contain Fe and have marked acid properties; they are soluble in alkalies.
- Chromo-proteids (compounds of a histon with hematin).
  - Hemoglobins (hematoglobulin, hematocrystallin)—oxygen-carriers; contain Fe; soluble in H_2O; $C_{600}H_{960}N_{154}O_{179}FeS_3$.
  - Vitellin—15 per cent. of yelk of hen's eggs; P and globulin and nuclein radical; hematogen = ferronuclein.
- Caseinogen (paranucleo-albumin, pseudonuclein)—1 per cent. of woman's milk, 3 per cent. of cows'; coagulated by rennet, forming calcium caseate; pptd. by excess of neutral salts or by acid (removes combining alkali); contains P, albumin, and a nuclein radical.
- Lecith-albumins—milk, stomach, and liver; albumin and phosphorized fat.
- Lardacein (amyloid substance)—friable, translucent, pathologic product in viscera; colored red by I, blue or violet by I and dilute H_2SO_4; soluble only in strong acids or alkalies.

Albuminoids, Glutinoids or Gelatinoids. **—In bones and protective parts; generally insoluble and indigestible; less C and S and more N than in other proteins.**

- Collagens, or glutins—white connective tissues, tendons, skin, and bones; gelatin (soluble in warm water) is hydrated ossein or collagen; gliadin is plant-gelatin; the only digestible albuminoids; tannin prevents putrefaction; purest source of gelatin is isinglass, or ichthyocolla (used in court-plaster); glue or size is impure gelatin from hides and parings; liquid glue, a solution in $HC_2H_3O_2$. Catgut (sheep-gut) is chiefly collagen. Gelatin is used for capsules and for coating pills and for clarifying beer and wine.
- Chondrin—in cartilage or gristle; very like collagen.
- Albumoid—cartilage; contains S; digested by gastric juice.
- Reticulin—reticular tissue (fibrous framework of lymph-glands, pulmonary alveoli and intestinal mucous membrane).
- Eleidin—intermediate between keratins and protoplasm; stratum granulosum of skin.
- Elastin—yellow connective tissue, fasciæ, aortic walls and ligaments; contains no S; hard and brittle when dry; converted during digestion into elastoses (like albumoses).
- Fibroin—chief constitutent of silk; covered with a glue, sericin.
- Chitins—skeletons of invertebrata.
- Spongin—chief ingredient of sponges.
- Enzymes—nucleo-proteids probably; optically active (see "Ferments").
- Hexone bases (containing 6 C), lysin, arginin, histidin, obtained from albumins by splitting with mineral acids, are of theoretic interest only.

General Protein Reactions.—Use 2-per-cent. solution of egg-albumin and of pepton; a number of tests should always be employed.

Biuret Test (Diamid Group).—Add an equal volume of strong KHO, heat to boiling, and add 1 or 2 drops of very dilute $CuSO_4$. All proteins give a violet color except gelatin (bluish violet in the cold) and albumoses and peptons (purple-red in cold). Biuret has the formula $C_2O_2N_3H_5$. When heated it gives off NH_3, leaving cyanuric acid, $C_3H_3N_3O_3$.

Millon's Reaction (Oxyphenol Group.)—The reagent is prepared by dissolving Hg in an equal weight of HNO_3, keeping cold at first, then using gentle heat, and when dissolved adding 2 volumes of H_2O. A few drops added to albumin solutions give a white ppt., turning red on boiling.

Xanthoproteic Reaction (Nitro-products of Phenol and Tyrosin).—Add an equal volume of HNO_3 and boil, getting a yellow ppt. or solution, which turns orange-yellow on cooling and adding excess of NaHO.

Adamkiewicz's Reaction (Indol and Skatol).—Mix 2 c.c. of H_2SO_4 with 4 c.c. of glacial acetic acid and add a fragment of the dry protein or a drop of concentrated solution. On slightly warming, a beautiful reddish-violet color appears.

Liebermann's Reaction (Non-aromatic Groups).—To 2 or 3 c.c. of HCl add 1 or 2 drops of undiluted egg-albumin, and boil several minutes, getting a pink or violet color.

Ammonia Test.—Mix dry protein with excess of soda-lime, and heat in a dry test tube; test vapors for NH_3.

Precipitation Reactions.—By coagulation, which is favored by presence of NaCl, especially albumoses.

Heat.—Ppts. serum-albumin about 50° (75° if salt be present); egg-albumin (54°); plant-albumin at 61° to 63°; myosin (40° to 50° in salt solution) and vitellin (75°); fibrinogen (56°) and globulin (75°), but not acid or alkali albumin, albumoses (clears up ppt.), peptons, or gelatin.

Acids.—Nitric best by contact—on boiling, acid albumin forms and ppt. dissolves. Phosphotungstic and phosphomolybdic acids ppt. all proteins in presence of HCl. A solution of phosphotungstic acid is prepared by adding H_3PO_4 to a hot solution of sodium tungstate till quite acid, then acidulating more strongly with $HC_2H_3O_2$, and filtering after standing a few hours.

Strong $HC_2H_3O_2$ *and* K_4FeCy_6 *(10 per cent.).*—A very delicate test for all proteins except peptons: 1 or 2 drops of each to 5 c.c. of solution.

Metallic Salts.—$(KI)_2HgI_2$ and $HgCl_2$ (ppt. dissolved by NaCl solution).

Br Water.—Sticky yellow ppt. with gelatin.

Alcohol.—In large excess ppts. all proteins, and after a time, if strong, coagulates them.

$MgSO_4$.—Saturation ppts. globulins, not albumins.

$(NH_4)_2SO_4$. Heating with an equal volume of saturated solution ppts. all except peptons and solutions of alkali albumins in alkalies.

Tannin.—Ppts. pepton as well as others. Ppt. soluble in excess of protein, in lactic or acetic acid and in alkalies.

Polariscopy.—Serum albumin has a s. r. power of —62.6°; egg-albumin, —35.5°.

Staining.—Nucleoproteids (particularly chromatins) have acid characteristics and take up basic dyes; extranuclear proteids (chiefly basic) are stained by acid dyes.

Globulins are more readily salted out from solution than albumins; thus, half saturation with $(NH_4)_2SO_4$ ppts. globulins; complete saturation is necessary to ppt. albumins.

Separation of Chief Proteins.—Serum-globulin is pptd. by saturating with $MgSO_4$ at 30°.

Serum-albumin is pptd. from filtrate by saturating with Na_2SO_4 at 40°.

Albuminates are pptd. by neutralizing second filtrate.

Albumoses are pptd. by saturating third filtrate with $(NH_4)_2SO_4$. (Primary pptd. by saturating with NaCl; secondary, by NaCl in acid solutions. Protalbumose is pptd. by a 2 per cent. $CuSO_4$ solution; deuteroalbumose is not. Dysalbumose is formed by subjecting heteroproteose to the action of H_2O for a long time.)

Peptons are pptd. by adding tannin to fourth filtrate.

Gelatin in dilute solution resembles pepton, but is pptd. easily with alcohol or by saturating with $(NH_4)_2SO_4$. It is not pptd. by acetic acid, but by Br water, HCl and phosphotungstic acid. It responds to the biuret and xanthoproteic reactions but not to Millon's test.

Metallic salts are commonly absorbed as albuminates. The albuminate of Fe (ferrated albumin) appears in red-brown soluble scales or powder and contains about 20 per cent. of Fe. It is made by combining solution of ferric oxychlorid with dried egg-albumin in sufficient water, neutralizing with NaHO, and washing and drying on glass plates. Nucleids are metallo-nuclein compounds formed by dissolving the freshly pptd. oxid of the metal in pure nucleinic acid derived from yeast, the resulting nucleid being then pptd. by addition of excess of alcohol. The nucleids are soluble in water, and are quite stable. Ambrosin is a white, odorless, tasteless colloid substance extracted from the pollen of ragweed, and is thought to be the direct cause of hay fever.

The cells of bacteria consist of a protoplasmic substance without a nucleus, enclosed within a cellulose or albuminous envelope, which may swell and become gelatinous by taking up water. A supply of O is absolutely necessary to spore formation. Pathogenic bacteria thrive best at the body temperature; non-pathogenic, about 20°. Nearly all pathogenic microbes are facultative anaërobic. Unfixed cocci always show Brownian molecular movements and fluid currents.

FERMENTS.

These are substances which cause selective ("key in lock") chemic changes, chiefly hydrolysis, without themselves undergoing any appreciable change. They were so named because of the effervescent effect of yeast on sugar solutions, and are in effect colloidal catalyzers. They are classified as unorganized and organized. The presence of an electrolyte in the solution seems necessary to fermentation. Different ferments often work together, forming symbiotic products. $HgCl_2$, phenol and sulphites paralyze ferment action. Ferments are probably present in every cell, taking part in all vital changes. The liver contains at least eleven ferments. The presence of normal ferments in dead tissue leads to spontaneous decomposition (autolysis), with formation of acids and other products. The ferments of one organ have also a less marked lytic action (heterolysis) upon another organ. Tissue ferments are isolated by crushing tissues with quartz sand and then expressing tissue juices under a high pressure (300 to 500 atmospheres).

Unorganized ferments, or enzymes, are excreted by organized ferments or secreted by living tissue-cells. They seem to be related to nucleoproteids. They exist in animal cells in an inactive, more complex state, called zymogens (pepsin as pepsinogen), and become active when exposed to the air or to the action of acids or alkalies or to special activators (kinases). They are slowly diffusible, soluble in glycerin (when impure) and water, from which absolute alcohol, $Pb(C_2H_3O_2)_2$, or $(NH_4)_2SO_4$ ppts. them. They are capable of transforming a large amount of the substance affected. Enzymes are not quantitatively involved in the reactions which they set up, but time is a factor. The digestive ferments are mutually destructive, and each is destroyed by an opposite reaction to that of its normal medium. Fermentation is the breaking up of an organic substance brought about by an enzyme produced by living cells. It substitutes and supplements direct oxidation. The acid fermentation of undigested carbohydrates checks the putrefaction of undigested proteids.

Enzymes, as a rule, act best (optimum temperature) at or near the temperature of the human body. A low temperature inhibits their action, and all coagulate and lose their potency when heated in a moist state much above 40° (animal, 75°; vegetable, 80°). When dry they withstand a temperature of 150°. An excess of zymolytic products retards and stops ferment action for the time.

Ferments which break down proteins into simpler products are termed proteolytic; those that convert amyloses into sugars, amylolytic; fat-splitting ferments, steatolytic; curdling or clotting, coagulant; and those that change more complex to simple sugars, glycolytic. Proteolytic enzymes have been used for the removal of false membranes.

Reductases (reducing enzymes) reduce S to H_2S. Glucosid-splitting ferments are found in plants. In naming enzymes suffix *ase* to the stem of the name of the substance upon which it acts.

Of the vegetable enzymes diastase (maltin, amylase) is most important. It is derived from the gluten of sprouting cereals. It converts starch (3000 parts) into dextrins, then maltose. Diastase is really a mixture of amylase (liquefying and saccharifying) and amylocoagulase (ppts. soluble starch from its solutions). Diastatic action on three molecules of starch yields maltose and dextrin.

Malted barley contains two other ferments, the one acting on protein, the other on cellulose, dissolving the husk. Sweet extracts of malt are infusions of malted barley containing dextrins, maltose, and dextrose, and should contain the active ferments. Bitter malt extracts are simply weak beers. The diastase of blood-serum and lymph converts glycogen into dextrin and maltose.

Experiment.—Make a little starch paste; add a drop of an I solution and several drops of a good malt extract. Warm for twenty minutes at body temperature. Note changes in color (dextrins) and reducing action of final product on an alkaline copper solution.

Lactase converts lactose into two monosaccharose groups. Maltase (glucase) changes maltose into glucose; saccharase acts on cane-sugar. Inulase changes inulin into fructose. Pectinase converts the pectin jelly substance into a reducing sugar. Cellulase, or cytase, converts cellulose into sugar.

Emulsin, or synaptase, occurs in sweet and bitter almonds and other vegetable products. It is a white mass, which converts amygdalin into dextrose and HCN. A similar ferment has been found on parasitic plants growing on trees.

Papain (papayotin) is present in the milky juice of the paw-paw tree. It is a white, granular powder, proteolytic in action, with leucin as the end-product. It also curdles milk. It can act in a feebly acid, neutral, or alkaline medium.

Bromelin is another proteolytic ferment obtained from pineapple. It is capable of digesting 100 times its own weight of protein in a few hours, and is active in both acid and alkaline media. Myrosin is the essential enzyme of mustard. The yeast-plant (baker's or brewer's yeast) produces a glycolytic ferment (invertin) which changes cane-sugar to glucose and which is set free by the death of the cells. Zymase and endotryptase are other yeast-ferments, separated by pressure. Zymase causes alcoholic fermentation of glucose. Laccase is an oxidase which causes the darkening of the sap of the Japanese lac tree (forming lacquer) and other saps and juices.

Oxidases (oxygenases) are found in most plants, particularly in the green leaves. They yield O to other substances and at once reoxidize themselves. They turn tincture of guaiac blue by direct transference of the molecular O of the air. Peroxidases give up O, and reoxidize. They contain Mn, Fe, Al or Cu. Only on addition of H_2O_2 will they turn guaiac blue. Catalases do not reoxidize themselves from the air. They are agents in protoplasm which decompose H_2O_2 so that peroxidases can utilize the liberated O.

Experiment.—Emulsion of fresh alcoholic guaiac with water is turned blue by a piece of raw potato (oxygenases), but is not turned blue by blood or raw meat (peroxidases) until H_2O_2 is added. The bubbles of free O seen on pouring H_2O_2 on fluids or tissues shows the presence of catalases.

Animal ferments are the essential factors in digestion. They are usually extracted with glycerin, pptd. with absolute alcohol, and preserved in solution by antiseptics, such as 0.5 per cent. $CHCl_3$, 5 per cent. thymol, 1 per cent. $HC_7H_5O_3$, and 15 to 25 per cent. C_2H_5HO. Or the digestive juice may be treated several hours with dilute H_3PO_4, and then with lime-water, when the pptd. $Ca_3(PO_4)_2$ drags down the enzyme mechanically; the ppt. is dissolved in HCl and dialyzed.

The proteolytic enzymes include pepsin, trypsin, and erepsin. Pepsin is secreted by the stomach-glands as pepsinogen, and requires HCl to complete and render it active. Its action is favored by 0.1 per cent. NaCl and by dilute antiseptics; retarded by sugar, alkalies, tea, coffee, alcohol, excess of HCl, regurgitated bile, or metallic salts (except calomel). The U. S. P. preparation is capable of digesting 6000 parts of freshly coagulated egg-albumin in six hours. It is destroyed when in solution by heating to 55° C., or by treating with 0.5 per cent. soda. Trypsin (trypsinogen plus enterokinase) acts on proteins the same as pepsin, but more powerfully. It requires a slightly alkaline medium (0.3 per cent. Na_2CO_3). Erepsin converts peptons and albumoses into crystalline amido-acids. It is present in all the organs of the body. The pseudopepsin of the fundus and pyloric part of the stomach and of the glands of Brunner acts in an alkaline as well as an acid medium. Chymase is a specific ferment in the gastric juice which stimulates the action of the pancreatic ferments.

Amylolytic animal ferments include the ptyalin of saliva and the amylopsin of pancreatic juice. The former acts best on boiled starch. The last is aided by the presence of bile, and is identic in action with vegetable diastase, changing starch to dextrins, then isomaltose and maltose, and sometimes glucose. In young infants both these enzymes are deficient.

Experiment.—Show amylolytic action of saliva by chewing an oyster-cracker for ten or fifteen minutes, testing a little at short intervals for dextrins and maltose.

The glycolytic ferment invertase (invertin, lactase, maltase, sucrase) is the active agent in the intestinal juice, converting 200,000 parts of compound sugars to glucose. A similar ferment exists in the saliva and pancreatic gastric juice. There are also glycolytic ferments in the blood and other tissues and oxidizing ferments (oxidazes) in the blood. Maltase and other enzymes may exert reversed zymolysis: *e.g.*, change dextrose to maltose. Pancreatin, U. S. P., is a mixture of pancreatic ferments usually extracted from the fresh pancreas of the hog.

Steapsin (pialyn, lipase) is a fat-cleaving ferment present in the pancreatic juice and the bile. It splits oils and fats into glycerin and fatty acids. The latter form soaps with the Na_2CO_3 present, and these emulsify the remaining fats. Lipase is present in many vegetable substances.

Rennin (chymosin, lab-ferment) is a milk-curdling ferment produced by the stomach and the pancreas, especially of young animals, and acts best in an acid medium. Alkalies or excess of acid destroys it. For the action of rennin, as well as for the clotting produced by the fibrin-ferment of the blood and myosin-ferment of muscles, the presence of Ca salts is necessary. Fibrin-ferment (thrombin) probably comes from the disintegration of leucocytes and blood-plaques when the vessels have been injured. Coagulases include this thrombase and rennet. It is held by some that the milk-curdling ferment is identic with pepsin and with trypsin.

Histozym is a ferment in the kidneys which converts benzoic into hippuric acid and glycocoll. There may be two ferments in the liver: one to dehydrâte glucose into glycogen, the other to change glycogen to glucose; or else a single enzyme (from pancreas) acts in both ways.

To explain the action of enzymes we may assume either that they combine with starch, sugar, or proteins to form hydrates with H_2O and then split off the enzyme; or that their molecular vibrations coincide with those of the fermentable

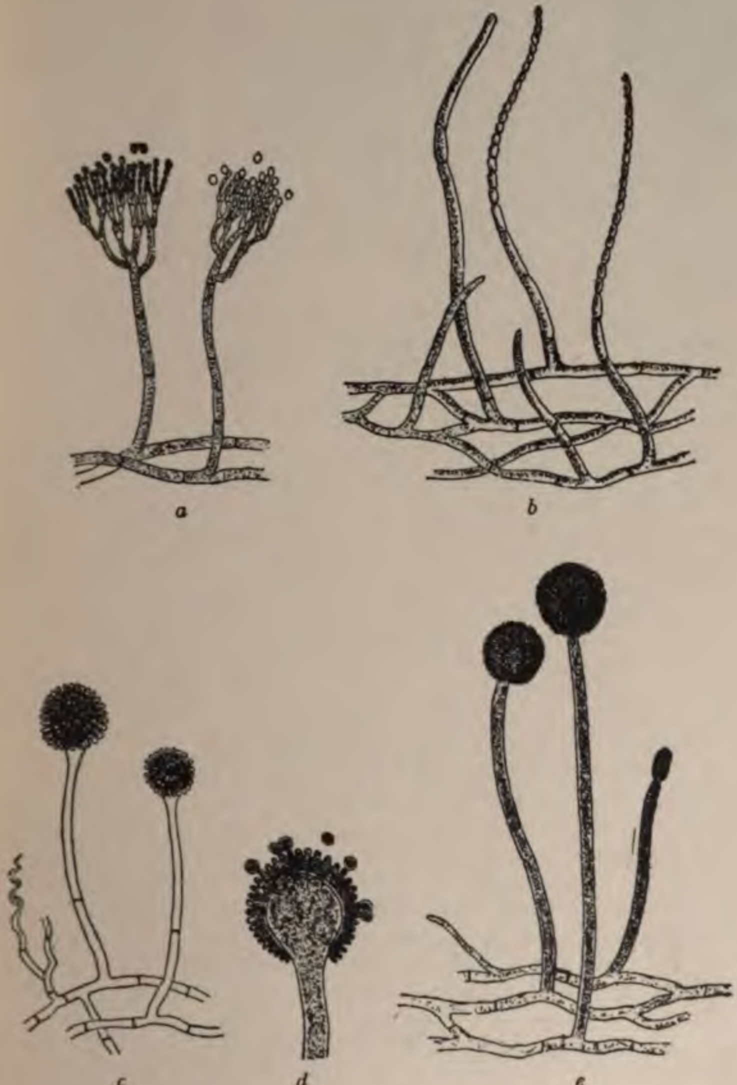


Fig. 40.—Molds. (*Baumgarten.*) (From Oertel, courtesy of P. Blakiston's Son & Co.) *a*, Penicillium glaucum. *b*, Oïdium lactis. *c*, Aspergillus glaucus. *d*, The same more highly magnified. *e*, Mucor mucedo.

substance, and that they serve simply as catalyzing agents to liberate impulses.

The reversible action of the body enzymes doubtless plays a very important part in metabolism, by establishing a chemic equilibrium between the fermented substance and the products of its fermentation. Thus, fat is digested by steapsin in the intestine only when the resulting glycerin and fatty acids are removed about as fast as formed. In the tissue fluids, on the other hand, the dissociation products are in excess, the enzyme activity is reversed, and fat is deposited. During starvation the lipase acts directly, as during digestion, on the fat deposits of the body, and the fatty acids and glycerin of the cells diffuse into the blood.

Rennin, trypsin, diastase and other enzymes excite the formation of antibodies. Antibodies in turn, when injected in an active state into new animals, bring about the formation of still other antibodies.

Living or organized ferments ("active ferments") are low vegetable micro-organisms, mostly bacteria, acting best at 20° to 40° and causing both normal (proteolytic, amylolytic, glycolytic, and fat-cleaving) and pathogenic fermentation in the organism. They contain fat, cellulose, albumin, and salts. Unlike enzymes, their growth is checked by antiseptics (1 per cent. of NaF or $CHCl_3$). Heating to 100° kills them except a few spores, and absence of moisture inhibits their action. They act by virtue of unorganized enzymes which they secrete. A nuclease is an enzyme which has a bacteriolytic power on the organism which produced it, and sometimes on others also. Pyocyanase, a nuclease derived from B. pyocyaneus, has a bactericidal action on typhoid, cholera, diphtheria and plague bacilli.

The yeast-fungus *(Torula, Saccharomyces)* appears in oval budding forms of several varieties, present in the air and on fruits. It decomposes 95 per cent. of glucose to alcohol, but is killed when the latter becomes concentrated (yeast ceases to act at 14 per cent.). The soluble enzyme invertase, produced by yeast-cells, changes cane-sugar to glucose, which is further acted on by the yeast. $CHCl_3$ stops the alcoholic fermentation, but not inversion. HF destroys objectionable ferments, and does not interfere with yeast fermentation, thus increasing the yield of alcohol.

The yeast plant in air multiplies rapidly and oxidizes sugar into acetic acid, with hardly any formation of alcohol; anaërobically it forms alcohol and CO_2. Yeast fermentation takes place below 30°; butyric and acetic, above 30°. Common yeast inverts cane-sugar and maltose; kefir granules invert cane-sugar, maltose and lactose. S. cerevisiæ is the common beer yeast used by brewers and distillers. The natural fermentation of grapes is due chiefly to S. apiculatus and S. ellipsoideus, which grow upon this fruit.

Mycoderma aceti ("mother of vinegar") is made up of aërobic streptococci (Bact. aceti), which oxidize alcohol (containing phosphates and a little albumin or NH_4 salts) to acetic acid. Certain ester-producing bacteria change malt to wine. The mold, *Mucor mucedo,* causes alcoholic fermentation. The molds of medicinal syrups consist of Penicillium glaucum.

Oidium albicans (thrush, or sprue) is a mycelial growth (long, adherent cells) collecting in the oral cavities of poorly nourished individuals, and forming in part the tartar on teeth.

The bacilli lactici (14 varieties) and butyrici grow best without O, and cause, respectively, lactic- and butyric- acid fermentation of mucus, sugars, and proteins. Intestinal colic (from H) is due largely to their gaseous products. The bacillus butylicus, found on cereals, furnishes an inverting and a peptonizing ferment.

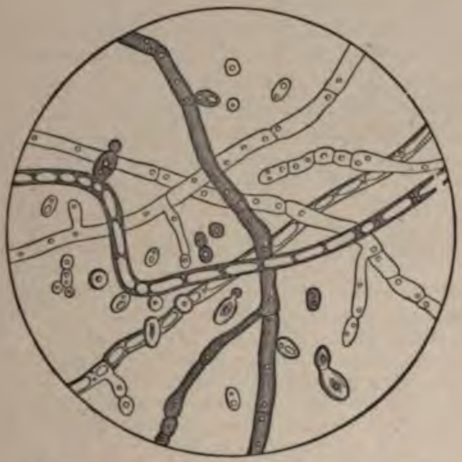


Fig. 41.—Soor [Thrush] Fungus. × 350.

The micrococci ureæ (ferment, urease) are the most common factors in the ammoniacal fermentation of urine, but urease is secreted by various other bacteria. They occur in air and in most soils and natural waters. Argenase is a urea-forming ferment in the body.

Putrefying ferments are both aërobic (outside body) and anaërobic (intestines—alkaline). They act mostly on proteins, the anaërobic producing H and fatty acids, then NH_3, H_2S, PH_3, CO_2, amins, amids, and phenol compounds, and finally peptons, toxalbumins, and ptomains.

Nitrifying ferments are oxidizing agents, converting NH_3 and albuminoids into nitrous and nitric acids, which, in contact with the mineral matters of the soil or of surface waters, form nitrites and nitrates, essential plant-foods. The rootlet nodules of beans, pease, clover, and other leguminosæ contain myriads of these bacteria, which enable the plants to utilize the nitrogenous matters in air and soil and even to fix the free N of the atmosphere.

The pathogenic organisms of specific infections excite diseases mainly by means of the toxins which they generate while rioting in the fluids of the body.

Colloidal Pt breaks up a million times its quantity of H_2O_2, and remains as strong as ever. It is also glucolytic and lipolytic in action. Certain substances (as H_2S or HCN with Pt) act as poisons or negative catalyzers, markedly retarding reaction, even when in very minute amounts.

Fermentation and putrefaction of foods are best prevented by cleanliness and freezing or cooking (various bacteria are able to survive temperatures as low as 0° or as high as 72°) and sealing in air-tight vessels, thus excluding the access of germs from the atmosphere. Salt acts as a preservative by removing the water necessary to bacterial growth.

QUESTIONS ON THE CARBON COMPOUNDS.

1. What is the present-day significance of the term organic?
2. Distinguish between a hydrocarbon and a carbohydrate.
3. How prove that a substance is organic?
4. How prove that a substance is nitrogenous?
5. Mention five petroleum derivatives.
6. Name three essential oils isomeric with turpentine.
7. Why is burning acetylene more luminous than methane?
8. Of what is benzene the source?
9. Distinguish chemically between an essential oil, a resin, oleoresin, a balsam, and a gum.
10. What are artificial fruit flavors?
11. Write equation for alcoholic fermentation of glucose.
12. What is "hard cider"?
13. Write graphic formulas for phenol, benzaldehyd, benzene, butane, salicylic acid.
14. Show by formulas the relations between the three classes of carbohydrates.
15. How distinguish by chemic tests between dextrose, maltose, and lactose?
16. Write equation for "fire-damp" explosion.
17. Explain drying of paints with turpentine.
18. Describe and explain the tests for the purity of $CHCl_3$.
19. What special precautions should be employed in using ether as an anesthetic?
20. Why are baking soda and ammonia suitable applications for insect- and nettle- stings?
21. Which contains more olein, lard or tallow?
22. What causes the curd when we use soap in hard water?
23. Mention three carbohydrates of animal origin.
24. Why is a mixture of dextrose and levulose called invert-sugar?
25. What is the difference between a ptomain, leucomain, and a toxin?

26. What is likely to be formed if we prescribe chloral hydrate with alkalies?

27. What official ointment contains elaidin?

28. What dangers in anesthesia from badly kept chloroform?

29. How are ink-stains removed by oxalic acid?

30. Explain spontaneous combustion of greasy rags.

31. Give formula of paraformaldehyd.

32. Give formula of acid radical (acetyl) of acetic acid; formula of basic radical. What is the difference in composition between alkyl radicals and acid radicals?

33. Does gallic acid tan leather, and why?

34. What makes garden rhubarb ("pie-plant") so sour?

35. Is ether-vapor lighter or heavier than air?

36. Write equation for reaction between Seidlitz powders.

37. How does clover restore the fertility of fields?

38. Explain the action of hair-dyes containing lead salts.

39. How distinguish the action of organized from unorganized ferments?

40. How does lemonade render the urine less acid?

41. What organic acid keeps the urine acid?

42. Why are the foulest-smelling stools alkaline?

43. Why is air needed to change weak alcoholic liquors to vinegar?

44. Why are alkaloids often preferred in medicine to the crude drugs and their preparations?

45. How is tea an antidote for alkaloidal poisons generally?

46. Why do animal substances putrefy readily?

47. How does butter become rancid?

48. Why is sweat sour?

49. What causes the very bad smell of some persons' feet?

50. How do sweet foods often cause a "sour stomach?"

51. Why does new cider cause diarrhea?

52. Why is "rot-gut" whisky so injurious?

53. How is bread raised with yeast?

54. How do alcoholics save the tissues in fever?

55. How are wines ripened?

56. How is glycerin produced in the body?

57. Explain the color-changes of litmus with acids and bases.

58. How test for the presence of carbolic acid in creosote?

59. Distinguish between an amid, an amin, an anilid, and an amido-acid.

60. Why should boiling water not be used in making a mustard plaster?

61. Calculate from formula the relative proportions of glycerin and oleic acid in triolein.

62. How could you separate castor-oil from other fixed oils?

63. Write equation for hydrolysis of cellulose with formation of methane.

64. Give the formulas of methyl chlorid, methene chlorid and methenyl chlorid.

65. Give another name for hydroxybenzene, carboxybenzene, amidobenzene, phenylcarbinol, phloroglucol, hydroxymethoxybenzene, orthohydroxycarboxybenzene, hydroxytoluene, allyl guaiacol, carbonyl diamid.

66. How may honey sometimes cause soreness and swelling of the mucous membrane of the mouth and throat?

67. Find a physic reason for the value of quinin in malaria.

68. How do alcoholics increase the toxic effects of tobacco?

69. What acid grows heavier on adding water?

70. What termination indicates an enzyme, a carbohydrate, an aldehyd, a compound containing hydroxyl?

71. A solution of sucrose in 250 parts of water is yet perceptibly sweet; in what dilution can saccharin be still perceived?

72. Why is bread sometimes sour?

73. How may granatum bark lose its activity on standing?

74. What should be the relative dose of opium as compared with morphin?

75. How do the Welsbach and other incandescent burners economize gas?

76. Explain white crystals formed on exposing essential oil of bitter almonds to the air.

77. How many gallons of CO_2 are produced by burning 10 gallons of acetylene?

78. Write equation for production of CO in manufacture of water gas.

79. Why does a raw cut apple or potato darken on exposure to the air?

80. What organized ferment can be found in the air of pastures and cowsheds?

81. Write equation for formation of butyric acid (with CO_2 and H) from glucose.

82. Determine molecular weight of serum-albumin.

83. What substance is classed as an acid and also as a glucosid?

ANALYSIS.

QUALITATIVE ANALYSIS.

GENERAL DIRECTIONS AND REMARKS.

Do NOT test an aqueous solution for compounds insoluble in water. Only distilled water should be used.

As little of the reagents as practicable should be employed—seldom above 1 gm. or 1 c.c., except in the case of highly diluted reagents, such as H_2S solution.

When heating liquids in a test-tube, prevent "bumping" by oscillating the tube with a slight turn of the wrist.

In dissolving metals use as little acid as possible, then evaporate nearly to dryness in a porcelain dish, and take up residue with water before applying tests.

In separating a mixture of salts be sure to add excess of precipitating reagent, so as to throw down all of the salt tested for.

Pour off supernatant liquid before trying solubility of a sediment; in many cases it is best also to wash the sediment with water. If there is much sediment, take only a small portion for each test of solubility.

If a powdered substance is insoluble in water, try dilute, then strong HCl, then HNO_3 or aqua regia. All these failing, make soluble by fusing with a mixture of carbonates of Na and K; the insoluble sulphates of alkaline earths are thus converted into carbonates, soluble in HCl after filtering away the soluble alkaline sulphates that are formed. Insoluble salts may also be boiled with strong NaHO; then dilute, filter, and test filtrate with usual reagents.

Silicates are readily dissolved with HF. Calcined oxids of Al, Cr, and Fe are rendered soluble by heating with 6 to 10 times their weight of $KHSO_4$ in a covered crucible until melted; the fused mass after cooling is dissolved in water. SnO_2 and Sb_2O_3 are made soluble by heating the powder with 4 to 6 times its weight of a mixture of equal parts of anhydrous Na_2CO_3 and S, until the S no longer burns from beneath the crucible cover.

An acid reaction to litmus does not necessarily indicate a free acid or an acid salt, since many normal salts, especially sulphates, are acid in reaction.

Decrepitation on heating is due to expansion of water in the crystals. Deflagration, or the vivid combustion of charcoal

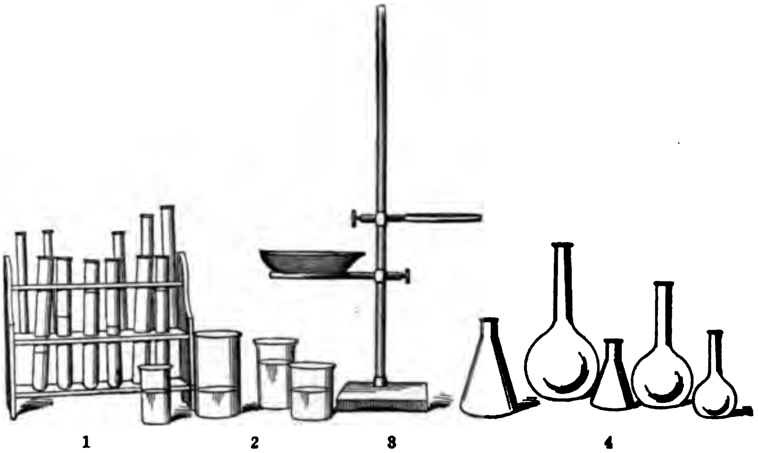


Fig. 42.—Apparatus for Solution. (*Rockwood.*) 1, Test-tubes in wooden supports. 2, Beakers. 3, Iron stand with adjustable rings for supporting objects while they are heated. On one of the rings is a sand-bath. 4, Flasks.

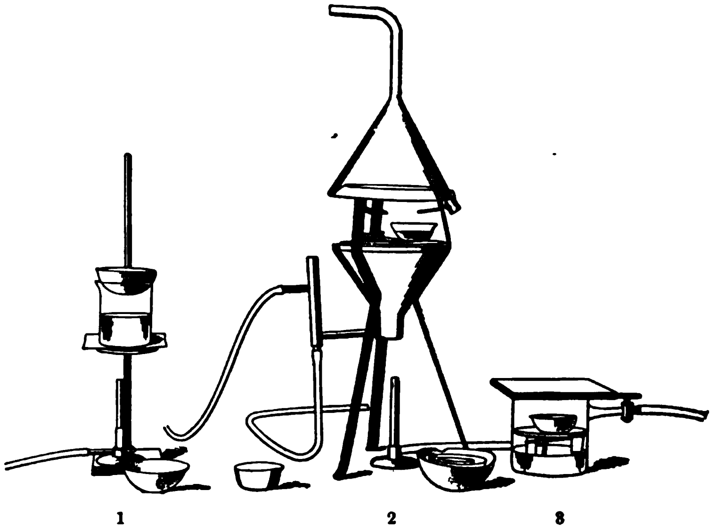


Fig. 43.—Apparatus for Evaporation. (*Rockwood.*) 1, An extemporized steam-bath—a beaker of water on which a dish can be heated. 2, A copper steam-bath with tubes supplying water and allowing the excess to escape, thus maintaining a constant level. The funnel above excludes dust. 3, A sulphuric acid vacuum-desiccator connected with air-pump. In front are evaporating dishes of porcelain, platinum, and glass.

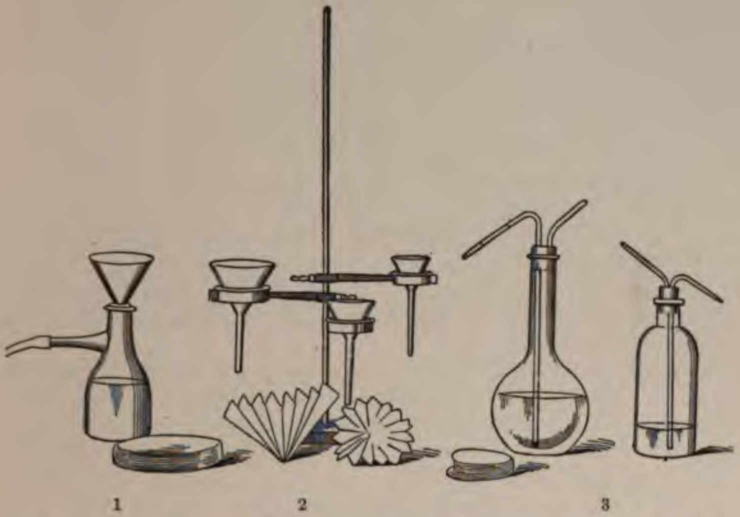


Fig. 44.—Apparatus for Filtration. (*Rockwood.*) 1, A funnel fitted to a filtering flask which is connected with a pump for the production of a vacuum, and consequently an increase in the rapidity of the filtration. 2, A support holding funnels for filtration. 3, Washing bottles. In front are packages of filter-paper with two plaited filters.

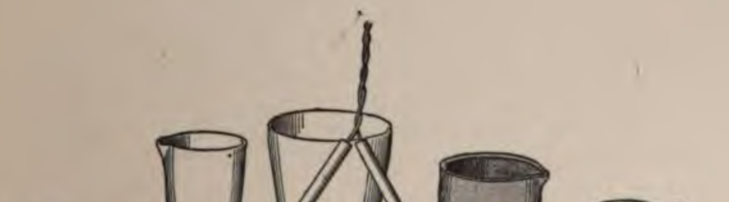


Fig. 45.—Apparatus for Fusion. (*Rockwood.*) 1, Porcelain crucible. 2, Hessian or clay crucibles, with a pipe-stem triangle leaning against middle one. 3, A graphite crucible. 4, A platinum crucible with cover. In front are forceps and crucible tongs.

when some substances are heated with the blow-pipe on it, is caused by certain oxidizing agents, particularly chlorates and nitrates.

In making tests in which color or opacity is a distinctive feature, it is well always to compare with distilled water, or with the results of reactions obtained with the substance whose presence is suspected. Color comparisons should be made near an unscreened window through which light reflected from the sky (not direct sunlight) falls upon the colored object from behind the observer. Solid substances should be placed upon a piece of white cardboard, and solutions should be inspected with a white surface as a background (black screen for testing the color of a fluorescence). The shades and tints of colors are modified by degree of concentration and by temperature, and often change quickly on standing.

Reduction on charcoal is usually best accomplished by heating with the blow-pipe the finely-powdered substance, placed in a hollow in the charcoal after mixing with twice its weight of dry KCN and Na_2CO_3. Incrustations around the heated spot are due to oxids.

Sublime and volatile substances, such as As, are easily recognized by heating in a bent dry glass tube open at both ends, and noting the mirror, or deposit of drops or crystals recondensed in the cooler part of the tube.

To separate the metals from each other, we employ a small number of group reagents, each of which throws down a certain group of metals—more quickly when heated. HCl is the general reagent of the first analytic group (Ag, Pb, Hg^I), throwing down an insoluble chlorid of each or all of these metals. H_2S (preferably the gas, added to solution previously acidulated with HCl) ppts. as sulphids the metals of the extensive second group, which is further subdivided according as the ppt. is soluble or insoluble in NH_4HS [made by saturating NH_4HO with excess of H_2S, forming the yellow $(NH_4)_2S$]. This latter solution (after supersaturating—equal volumes—with NH_4HO) ppts. the members of the third group in neutral solutions. $(NH_4)_2CO_3$ (1 part of commercial salt dissolved in a mixture of 4 parts of H_2O and 1 part of NH_4HO) ppts. the alkaline earths (in alkaline solutions), which constitute the fourth group. An aqueous 10-per-cent. solution of Na_2HPO_4 is the reagent for Mg, or the fifth "group," which is kept in solution by NH_4Cl till now. The metals of the alkalies are left in the final filtrate. These reagents must be used only in order mentioned, and must generally be added in excess in order to ppt. the total quantity of metal or metals in each group, which is separated by filtration before passing to the next group. Heating facilitates complete precipitation.

FINDING THE METAL.

GROUP I (Pb, Ag, Hg^{I}).
(Group reagent = HCl.)

White ppt.
- $PbCl_2$—soluble in boiling water.
- $AgCl_2$—insoluble in H_2O; soluble in dilute NH_4HO (1 to 10).
- HgCl—insoluble in H_2O and turned black by NH_4HO.

Separation.

1. Pb dissolved out with boiling H_2O and repptd. from filtrate with dilute H_2SO_4.
2. Ag dissolved from first residue with dilute NH_4HO and repptd. with HNO_3.
3. Hg, if present, left as a black residue from filtration of Ag.

GROUP II (Hg^{II}, Bi, Cu, Pb, Cd, Sb, As, Sn^{II-IV}, Pt, Au).
(Group reagents = HCl [a few drops] and H_2S [excess].)

Division I (ppt. insoluble in yellow NH_4HS).

Yellow ppt. = CdS.

Blackish ppt.
- HgS — brownish yellow, then black.
- Bi_2S_3
- CuS.
- PbS.

O (original) + KHO
- Yellow = Hg.
- Blue = Cu (decolorized by KCN). O + $K_4Fe(CN)_6$ gives a brown-red color or ppt.
- White
  - Bi—insoluble in excess of KHO (yellow oxid on boiling).
  - Pb — soluble in excess of KHO.

Division II (ppt. soluble in yellow NH_4HS on digesting in an evaporating-dish).

Orange ppt. = Sb_2S_3.

Brown or blackish ppt.
- SnS. O + $HgCl_2$ on boiling gives a gray ppt.
- PtS_2. O + KCl + C_2H_5HO gives a yellow ppt. (K_2PtCl_6).
- Au_2S_3. O + $SnCl_2$ gives a purple ppt.

Yellow ppt.
- As_2S_3—heated with KCN and Na_2CO_3 in a bent glass tube gives a black metallic mirror above.
- SnS_2 — O + KHO gives a white ppt., soluble in excess, not repptd. on boiling.

Separation.

First Division
1. Boiling dilute HNO_3 dissolves all ppts. except HgS (black residue soluble in aqua regia).
2. Dilute H_2SO_4 throws down Pb (white) from above solution after expelling HNO_3.
3. Strong NH_4HO throws down Bi (white) from filtrate of No. 2. Filtrate of No. 3 blue if Cu is present.
4. H_2S ppts.
   - yellow = Cd.
   - black = Cu (decolorized and kept in solution by KCN while Cd is pptd. with H_2S).

Second Division

- 1. Boiling HCl ppts.
  - As—yellow if alone, blackish if Au or Pt present; soluble in $(NH_4)_2CO_3$, repptd. by HCl.[1]
  - Au, Pt — Residue from As, soluble in aqua regia
    - Au pptd. by $FeSO_4$.
    - Pt pptd.[2] (yellow) from filtrate by KCl + C_2H_5HO.
- 2. Filtrate may contain Sb, Sn
  - Separated by electrolysis between a piece of Pt (Sb forms a black coating insoluble in boiling HCl) and a strip of Zn.
  - Sn, if present, is deposited as a loose, metallic sediment.

Group III (Fe, Co, Ni, Cr, Al, Ce, Mn, Zn, $Ca_3[PO_4]_2$).

(Group reagents = NH_4Cl, NH_4HO [till alkaline], and NH_4HS.)

Division I (ppt. formed by NH_4HO turned black by NH_4HS).

Black color bleached by HCl = $Fe(HO)_3.O$ + K_3FeCy_6 (ferrous) or K_4FeCy_6 (ferric) gives a blue ppt.

Black residue from HCl

- CoS. O + KHO gives bluish ppt., turning pink on boiling.
- NiS. O + KHO gives green ppt., unaltered on boiling.

Division II (ppt. formed by NH_4HO unchanged in color by NH_4HS).

Green ppt. = $Cr(HO)_3$. Solution in dilute HCl is violet.

White ppt.

- $Al(HO)_3.O$ + KHO gives a white, gelatinous ppt., soluble in excess, repptd. by boiling with excess of NH_4Cl.
- $Ce(HO)_2$, $Ca_3(PO_4)_2$ — O + KHO gives a white ppt. insoluble in excess.
  - Ce leaves a red residue on evaporating and heating.
  - $Ca_3(PO_4)_2$ is soluble in $HC_2H_3O_2$

Division III (ppt. with NH_4HO instantly soluble, but NH_4HS gives a light-colored ppt.).

Flesh-color ppt. = MnS — fused on Pt foil with Na_2CO_3 and KNO_3 forms a green mass of K_2MnO_4.

White, gelatinous ppt. = ZnS — moistened with a drop of $Co(NO_3)_2$ and heated on charcoal it turns green.

Separation.

1. HCl dissolves all the group ppts. except Co and Ni, which are separated by dissolving in aqua regia, then adding KHO in excess; Ni is pptd., and Co is obtained from filtrate by evaporation.

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[1] As can be separated from Sb by pptg. with H_2S, dissolving in NH_4HS, filtering, evaporating, treating residue with HNO_3 and KOH (converts the metals into potassium arsenate and antimonate), putting the mixture with Zn and H_2SO_4 into a Marsh apparatus, passing the gas through a solution of $AgNO_3$ as long as black ppt. (silver antimonate) forms, then separating As in solution by filtration.

[2] In testing for K with $PtCl_4$ and alcohol, any NH_4 salts must be removed by boiling with $Ca(OH)_2$.

2. Evaporate HCl solution nearly to dryness, take up with water, boil with excess of KHO, and filter, saving precipitate.
3. NH_4Cl ppts. Al (white) on boiling with filtrate of No. 2 and standing.
4. NH_4HS ppts. Zn (white) from filtrate of No. 3 on standing.
5. Fuse ppt. from No. 2 on Pt with Na_2CO_3 and KNO_3; a green mass indicates Mn. Treat mass with boiling water, filter, and save residue for Fe; ppt. Mn (white) with K_4FeCy_6 and filter again.
6. Acidulate second filtrate from No. 5 with $HC_2H_3O_2$ and ppt. Cr (yellow) with $Pb(C_2H_3O_2)_2$.
7. Dissolve residue from No. 5 in dilute HCl, and ppt. Fe (blue) with K_4FeCy_6.
8. When phosphates are present, boil filtrate from Group II till all H_2S is expelled; add a few drops of HNO_3; heat to boiling again; add NH_4Cl, NH_4HO, and NH_4HS; and filter, reserving this filtrate, containing phosphates, for the fourth and fifth groups.

GROUP IV (Ba, Ca, Sr).

(Group reagents $= NH_4HO$, and $[NH_4]_2CO_3$.)[1]

White ppt.
- $BaCO_3.O + K_2CrO_4$ gives a yellow ppt.
- $CaCO_3.O + (NH_4)_2C_2O_4$ gives a white ppt.
- $SrCO_3$ — crimson flame.

Separation.

1. Dissolve group ppt. in $HC_2H_3O_2$.
2. $K_2Cr_2O_7$ ppts. Ba (yellow); yellow color of filtrate removed by repptg., washing with water and again dissolving.
3. Dilute K_2SO_4 ppts. Sr (white) on standing, from filtrate of No. 2.
4. $(NH_4)_2C_2O_4$ ppts. Ca (white) after rendering filtrate of No. 3 alkaline with NH_4HO.

GROUP V (Mg).

(Reagents $= NH_4HO$ and Na_2HPO_4.)

White ppt. $= NH_4MgPO_4$ — feathery crystals under microscope. Rub inside of tube gently with glass rod, and let stand.

GROUP VI.

Flame Tests: Na, yellow (shut off by cobalt-blue glass); K (and NH_4), violet; Li, carmine red.

Odor Test: Boiling O with KHO gives odor of NH_3 and vapors, turning moist red litmus-paper blue.

Precipitation
- Na_2HPO_4 and NaHO ppt. Li (white), soluble in acids and in NH_4Cl.
- Sodium cobaltic nitrite $[Co_2(NO_2)_6.6NaNO_2]$ ppts. K (yellow) in presence of acetic acid. $NaHC_4H_4O_6$ in neutral solution gives white ppt. on standing (rub glass inside with rod)—made more delicate by adding a trace (inoculation) of a mixture of 1 part $KHC_4H_4O_6$ and 99 parts $NaNO_3$ (removes supersaturation). Ammonium hydrogen tartrate is also difficultly soluble.

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[1] First get rid of NH_4HS by heating filtrate from third group with $HC_2H_3O_2$ (filter out any S which separates); render alkaline with NH_4HO, and heat to boiling.

Separation

1. Na_2HPO_4 and NaHO, boiling till all NH_3 is expelled, ppts. Li_2HPO_4. $LiCl_2$ is soluble in a mixture of alcohol and ether.
2. Sodium cobaltic nitrite ppts. K from filtrate of No. 1, after acidulating with $HC_2H_3O_2$.
3. Test original solution for NH_3 by boiling with KHO. The amount of gas can be estimated volumetrically by passing into a standardized HCl solution.
4. Na is tested in O by flame test, and is estimated gravimetrically by subtraction of all other ingredients from the total solids. Na salts are pptd. (white) with a fresh solution of potassium antimonate, $K_2H_2Sb_2O_7$.

NOTES.

HCl may ppt. oxychlorids (soluble in excess) of Sb or Bi from solutions of certain compounds of these metals. It also ppts. silica from soluble silicates, and oxids or hydroxids [$Zn(HO)_2$, for instance] previously dissolved in alkaline hydroxids (insoluble in HCl).

The solution must be acidified before adding H_2S, since in a neutral or alkaline solution some metals of the second group are not pptd. by this gas, whereas other metals of the third group are pptd.

S is sometimes pptd. on addition of H_2S, with or without a change in color (red-brown ferric compounds become green ferrous; fluids containing chromates turn green), owing to the deoxidizing action of H_2S, the H becoming oxidized to water, while S is set free. For this reason, H_2S or yellow ammonium sulphid should not be employed in a solution containing free HNO_3.

When the first group reagent fails to yield a ppt. add H_2S to the same tube. When reagents of third group show no ppt., add to same fluid $(NH_4)_2CO_3$ for fourth group, and Na_2HPO_4 for fifth group. Boil filtrate from second group with a few drops of dilute HNO_3 before adding group reagents; a yellow color shows Fe probably.

Dilute H_2SO_4 ppts. all the members of the second division of the second group from solution in NH_4HS. Acids added to yellow ammonium sulphid (polysulphid) form a soluble NH_4 salt and ppt. S (white and milky), which should not be mistaken for the members of the arsenic division.

The third group reagents ppt. also phosphates, borates, oxalates, and silicates of Mg and alkaline earths from their solutions in weak acids.

The reagent ammonio-silver nitrate is prepared by adding NH_4OH cautiously to $AgNO_3$ solution till the brownish ppt. first formed nearly dissolves. The reagent ammonio-copper sulphate is formed similarly by the addition of NH_4OH to $CuSO_4$.

FINDING THE ACID, OR RADICAL.

RESIDUES—PROBABILITIES.

(If a liquid, notice reaction to litmus and evaporate to dryness, then heat to redness.)

No Residue:

Neutral: water (no odor).

Strongly acid: some volatile acid (acetic, hydrochloric, nitric, etc.).

Residue:

Strongly acid:

Fusible by heat: non-volatile mineral acids (phosphoric).

Residue chars on heating: free organic acid (tartaric, citric, etc.).

- *Neutral or slightly acid:*
  - Residue volatile with fumes, but without blackening: salt of volatile metal (NH_4, Hg, Sb, As).
  - Residue blackens and volatilizes in fumes: organic salt of some volatile metal.
  - Residue changes color on heating:
    - Yellow hot, cooling white = Zn.
    - Deep-yellow hot, cooling yellow = Pb.
    - Yellowish brown hot, cooling pale yellow = Sn^{IV}.
    - Orange-yellow hot, cooling lemon-yellow = Bi.
    - Red hot, cooling reddish brown = Fe or Ce.
    - Permanent brownish black = Mn.
  - Residue white, darkens on heating, burns and leaves black or grayish mass: organic salts of fixed metals.
    - Alkaline residue = K, Na, Li.
    - Non-alkaline residue, effervescing with $HC_2H_3O_2$ = Ba, Sr, Ca.
  - Residue that takes fire and continues to burn after removal from flame with dense, white fumes = hypophosphite.
- *Strongly alkaline:* leaving fixed white alkaline residue.
  - Acidulate some of original with HCl:

Effervescence:
- *Without smell* = carbonates or bicarbonates of K, Na, or Li.
  - O + $HgCl_2$ gives a red (carbonate) or white (bicarbonate) ppt.
- *With smell:*
  - Of H_2S = sulphid of alkali or alkaline earth. (Sulphids of Hg, Au, Pt and FeS_2 are not decomposed by the acid unless Zn is added.)
  - Of HCN = alkaline cyanid.

No Effervescence. Add $AgNO_3$ to original:
- *Brownish black* = hydroxid of alkali or alkaline earth.

Yellow = phosphate *White* = borate *Brick-red* = arsenate	of K or Na.

PRELIMINARY EXAMINATION OF SOLID ACIDS AND SALTS.

Step I.—Heat a portion of the powdered substance on Pt foil:
- *Charring:* organic acids or salts (except oxalates), sugar (reduces cupric solution), or alkaloids (odor like burning hair).
- *Ignition:* C, S, P, and all organic compounds; also hypophosphites (garlicky odor).
- *Decrepitation:* NaCl and other salts containing H_2O.
- *Deflagration:* chlorates, nitrates, nitrites, iodates, etc., on charcoal.
- *Irritating Vapors:* benzoic acid.
- *Fusible:* most salts of alkalies and some of alkaline earths.
- *Infusible:* salts of earths and most silicates and salts of alkaline earths and heavy metals.

Step II.—Put a portion in tube, cover with water, and render barely acid with dilute H_2SO_4:
- *Red vapors:* nitrites.
- *Effervescence:*
  - Without odor: carbonate—evolved gas renders lime water milky (a drop of $Ca(OH)_2$ may be held on glass rod in tube).
    - Peroxids of alkali and alkali earth metals: oxygen.
  - With odor:
    - Sulphid: like sewer-gas; turns lead-paper black.
    - Sulphite: like burning sulphur (SO_2). A drop of $K_2Cr_2O_7$ held on a glass rod in tube turns green.
    - Thiosulphate: odor of SO_2 and ppt. of S.

Cyanid: odor of HCN.
Hypochlorite: chlorin odor, greenish-yellow fumes.

Step III.—Add another drop of H_2SO_4, and warm again. These effects often occur in the second step:

Characteristic odors:

Vinegar = acetate: odor of acetic ether on adding alcohol.
Sulphur dioxid = hyposulphite: with deposit of S.
Carbolic acid = carbolate: a few drops of $FeCl_3$ give a violet color.
Valerian = valerianate: Cu $(C_2H_3O_2)_2$ added to distillate forms a slow, oily ppt., gradually solidifying into greenish-blue crystals.
Benzoic acid = benzoate: light-red ppt. with $FeCl_3$ in presence of enough NH_4OH to render slightly alkaline.
HCN:
  With deposit of S = sulphocyanid: blood-red color with $FeCl_3$.
  Crystalline deposit, often bluish:
    Ferrocyanid: ferric salts give a blue ppt.
    Ferricyanid: ferrous salts give a blue ppt.

Step IV.—Put a little O (original solid) in a dry tube, cover with strong H_2SO_4 drop by drop, and warm gently, keeping the acid below b.p.:

White fumes:

Chlorid: odor of HCl; $AgNO_3$ gives curdy white ppt., soluble in NH_4OH.
Nitrate: faintly-reddish vapors, turning more red on addition of $FeSO_4$.
Fluorid: fumes etch glass.
Benzoate: very irritating vapors (see test above).
Succinate: $FeCl_3$ gives a brownish-red ppt.
Sulphocarbolate: same tests as for carbolates; also after fusion with KNO_3 and redissolving in dilute HCl it gives sulphate reaction with $BaCl_2$.
Ammonium compounds: dense, white fumes on holding near mouth of tube a glass rod dipped in HCl.

Colored fumes:

Violet vapors of I:
  Iodid: blue with starch paste and Cl water.
  Iodates: blue color with starch paste on adding KI and tartaric acid.
Brown vapors of Br:
  Bromid: orange color when mixed with starch paste and a few drops of Cl water.
  Bromate: deflagrates on charcoal, leaving corresponding bromid.
Brownish gas with peculiar odor: nitrite or nitrate.
Greenish-yellow gas = chlorates: explodes readily; spontaneous ignition of tissue-paper dipped in benzin when dropped into beaker containing chlorate and H_2SO_4.

Simple change in color:

Chromates: orange, then green.
Dichromates: turn green at once.
Oxids of heavy metals: darken by reduction to metallic state.

Effervescence on warming, with no odor or change in color:

Formate: gives off CO only, burns with bluish-lavender flame.
Oxalate: gives of both CO and CO_2, thus rendering lime-water milky.
Chromates, peroxids, permanganates: give off O.

Effervescence on warming, with darkening in color:

Tartrate: rapid charring and smell of burnt sugar.

Lactate: not so dark; odor of sour milk; odor of aldehyd on boiling with $KMnO_4$.

Citrate: slow darkening, with slight odor of burnt sugar.

Oleate: charring, with sharp, disagreeable odor of acrolein.

Darkening in color without any very marked effervescence:

Tannate: solution forms black ink with $FeSO_4$; no ppt. with gelatin (unless gum is present).

Gallate: solution forms a black ink with $FeSO_4$; immediate brownish ppt. with gelatin.

Pyrogallate: solution turns blue with ferrous, red with ferric salts.

Salicylate: very slow darkening; deep-violet coloration with $FeCl_3$.

Meconate: red color with $FeCl_3$, not discharged by $HgCl_2$ or dilute HCl.

No fumes:

Silicate: gelatinous or flaky deposit.

Borate: scaly crystals with pearly luster, best seen on cooling.

No change whatever:

Sulphate: hepar test: heat with a little Na_2CO_3 on charcoal in inner blow-pipe flame (reduction to sulphid); residue placed on a clean silver coin moistened with H_2O and HCl leaves a black stain.

Phosphate: solution of $(NH_4)_2MoO_4$ in HNO_3 yields a yellow ppt. insoluble in HNO_3, soluble in NH_4OH.

Phosphite: heated with $AgNO_3$ yields ppt. of metal Ag; same reaction as phosphate, after heating with HNO_3.

Arsenate: boil with NaHO, filter, exactly neutralize filtrate with dilute HNO_3, add $AgNO_3$ and get brick-red ppt.

Arsenite: $AgNO_3$ gives canary-yellow ppt. of Ag_3AsO_3, soluble in excess of NH_4OH or HNO_3.

Alkaline oxids: soluble in HCl or HNO_3 without effervescence; negative findings as to acid radicals except that of solvent.

DETECTION OF ACIDS AND ACIDULOUS RADICALS (ANIONS) IN SOLUTION.[1]

$AgNO_3$, Reagent:

Neutral or acid (HNO_3) reaction:

White ppt.:

HCl or chlorids: curdy ppt. insoluble in boiling HNO_3, but instantly soluble in dilute NH_4HO (1 to 20); hypochlorites give same reaction, with odor of Cl.

HBr or bromids: dirty-white ppt., insoluble in HNO_3, slowly soluble in strong NH_4HO (not in dilute).

HCN or cyanids: curdy ppt. with bitter-almond odor, sparingly soluble in NH_4OH, in strong boiling HNO_3, but not in dilute HNO_3; does not blacken on exposure to light, as chlorid and bromid do.

Ferrocyanids: gelatinous ppt., scarcely dissolved by NH_4OH; ferric solutions give a dark-blue ppt., insoluble in HCl.

Sulphocyanid: soluble in KCN, ammonia or $Na_2S_2O_3$; turns blood-red on adding a ferric solution.

Nitrites: white ppt. in strong solutions; $O + HC_2H_3O_2$, KCNS and then HNO_3, gives a deep-red coloration, disappearing on heating.

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[1] Find metal or metals present before testing for acid radicals; then test for the salts of the metal known to be soluble. If O (evaporated) does not char on heating with H_2SO_4, no organic acids or salts except $H_2C_2O_4$ can be present.

Light yellow = HI or alkaline iodids: ppt. does not dissolve in hot HNO_3 and is practically insoluble in NH_4OH.

Black ppt.:

H_2S or sulphids: sewer-gas odor often noticeable on treating with a mineral acid.

$HCHO_2$ and formates: metallic Ag separates on boiling.

$HC_3H_5O_3$ and lactates: dark ppt. on boiling, leaving a blue liquid on subsidence.

Hydrates: dark-brown ppt., soluble in NH_4OH.

Neutral reaction:

White ppt.:

H_2SO_3 and sulphites: soluble in NH_4HO or HNO_3; turns black on heating.

H_2SO_4 and sulphates: no reduction on heating.

H_2CO_3 and carbonates: effervesce with cold acids generally, evolved gas turning lime-water milky.

H_3BO_3 and borates: ppt. soluble in HNO_3 or NH_4OH; green flame on igniting with alcohol in case of solid acid.

$H_2C_2O_4$ and oxalates: soluble in NH_4OH and in hot concentrated HNO_3; acid decolorizes $KMnO_4$ solution.

$H_2C_4H_4O_6$ and tartrates: turns black on boiling; silver mirror on warming mixture after adding just enough NH_4OH to dissolve ppt.

$H_3C_6H_5O_7$ and citrates: no mirror of Ag on boiling; both this and that above char on heating in solid form.

H_3PO_3 and phosphites: turn black, from metallic Ag.

Hypophosphites: soluble in excess; turns yellow, brown, and black (reduction). O heated with $HgCl_2$ yields calomel, then black Hg.

Meta- and pyro- phosphates: soluble in HNO_3 and in NH_4OH.

Thiosulphates: white ppt. on adding excess of reagent—soon turns yellow, brown, and black (Ag_2S), more quickly on heating.

Acetates: leafy crystals, soluble in NH_4OH or in excess of H_2O.

Yellow ppt.:

H_3PO_4 and phosphates: lemon-yellow ppt. soluble in HNO_3 and in NH_4OH. O gives with solution of $(NH_4)_2MoO_4$ in HNO_3 a yellow ppt., which is insoluble in HNO_3, but soluble in NH_4OH.

H_3AsO_3 and arsenites: canary-yellow ppt. with argent-ammonium nitrate. soluble in excess of NH_4OH or HNO_3.

Reddish ppt.:

H_3AsO_4 and arsenates: brick-red ppt. soluble in HNO_3 or NH_4OH.

H_2CrO_4 and chromates: dark-red ppt., soluble in HNO_3 and in NH_4OH.

Ferricyanids: orange ppt. soluble in NH_4OH, KCN or $Na_2S_2O_3$. O + ferrous solutions gives a dark-blue ppt., insoluble in acids.

Alkaline (KOH) reaction:

Brown ppt.: antimonates: soluble in NH_4OH.

Dark ppt.: antimonites: insoluble in NH_4OH.

$BaCl_2$, Reagent:[1]

Neutral or alkaline reaction:

White ppt.:

H_2SO_4 and sulphates: insoluble in boiling H_2O and in boiling HNO_3; strong H_2SO_4 chars organic substances.

H_2SO_3 and sulphites: white ppt. produced on boiling with $BaCl_2$

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[1] $BaCl_2$ added to a strongly acid solution often causes the reagent to crystallize out—soluble in boiling water.

and Cl water or HNO_3 (forms sulphate)—$BaSO_3$ is soluble in HCl.

- H_2CO_3 and carbonates: soluble in HCl with effervescence.
- H_3PO_4 and phosphates: soluble in acetic and all stronger acids.
- $H_2C_2O_4$ and oxalates: insoluble in $HC_2H_3O_2$; soluble in HCl, HNO_3, or H_2SO_4.
- H_3BO_3 and borates: soluble in excess of water, in HCl, or NH_4Cl. Turmeric paper turns brown-red on drying, after dipping in hot solution of acid (borates must first be rendered just acid with HCl), becoming olive-green on treating with NH_4HO.
- $H_2C_4H_4O_6$ and tartrates: soluble in NH_4 salts or in HCl.
- $H_3C_6H_5O_7$ and citrates: soluble in HCl.
- Arsenites (see special tests for As).
- H_3AsO_4 and arsenates (see special tests for As).
- Thiosulphates: soluble in excess of water, and decomposed by HCl with pptn. of S.
- Fluorids: soluble in HCl, HNO_3 and NH_4 salts.
- Fluosilicates: difficultly soluble with K salts in acid solution.
- Phenolsulphonates: $FeCl_3$ colors violet.

Yellow ppt.:

- H_2CrO_4 and chromates: ppt. soluble in HNO_3 or HCl, insoluble in $HC_2H_3O_2$.

$FeCl_3$, Reagent:

Neutral or slightly acid:

- Yellowish ppt.:
  - H_3PO_4 and phosphates: light-yellow, gelatinous ppt. soluble in HCl. Avoid excess of $FeCl_3$.
  - $H_2C_2O_4$ and oxalates: soluble in HCl or HNO_3.
  - H_3BO_3 and borates: soluble in excess of reagent or in HCl; turmeric test (see under $BaCl_2$).
  - H_3AsO_4 and arsenates (see special tests).
- H_2CO_3 and carbonates: yellowish-brown $Fe(HO)_3$; CO_2 escapes.
- Reddish ppt.:
  - $HC_7H_5O_2$ and benzoates: flesh-colored or reddish-white ppt. (in slightly alkaline medium), soluble in acids, including benzoic.
  - $HC_2H_3O_2$ and acetates: reddish-brown coloration, pptg. on boiling; color discharged both by HCl and $HgCl_2$.
  - Sulphites: red-brown coloration.
  - Sulphocyanids: blood-red coloration, not destroyed by dilute HCl, but disappears on adding $HgCl_2$.
  - Pyrogallic acid ($C_6H_6O_3$): red solution.
  - $H_2C_7H_2O_7$ and meconates: red color, not discharged by $HgCl_2$ nor by dilute HCl.
- Black ppt.:
  - H_2S and sulphids: disgusting characteristic odor evolved on treating with HCl.
  - $HC_{14}H_9O_9$ and tannates: bluish black or greenish black, dissolved in excess of tannin, decolorized by HCl or $H_2C_2O_4$.
- Blue or violet ppt.:
  - Ferrocyanids: dark Prussian blue, decomposed by alkalies (reddish brown), insoluble in acids (restore blue color after treating with alkalies).
  - Thiosulphates ("Hyposulphites"): reddish violet, gradually disappearing by spontaneous reduction.
  - C_6H_5OH and carbolates: permanent reddish-violet color. O + excess of Br water gives white ppt. (tribromphenol).
  - $HC_7H_5O_3$ and salicylates: deep-violet coloration.
- Brownish: ferricyanids: brownish coloration, changed to blue ppt. on adding reducing agents (H_2SO_3 or $SnCl_2$).

$CaCl_2$, Reagent:

Neutral or alkaline:

White ppt.:

H_2SO_4 and sulphates: ppt. best secured by adding a half-volume of alcohol and shaking; ppt. dissolves readily in dilute HNO_3 or HCl, as also in saturated solution of KNO_3.

$Na_2S_2O_3$, or NH_4 salts.

Fluorids: soluble in acids.

H_2SO_3 and sulphites: O + strong acid yields odor of SO_2.

H_2CO_3 and carbonates: soluble in acids with effervescence.

H_3PO_4 and phosphates: soluble in acetic and all stronger acids.

H_3BO_3 and borates: in slightly alkaline solutions (NH_4OH); soluble in $HC_2H_3O_2$ and stronger acids.

H_3AsO_4 and arsenates (see special tests for As).

$H_2C_2O_4$ and oxalates: soluble in HCl or HNO_3, insoluble in $HC_2H_3O_2$.

$H_2C_4H_4O_6$ and tartrates: soluble in KHO, redeposited on boiling; also dissolved by $HC_2H_3O_2$.

$H_3C_6H_5O_7$ and citrates: white ppt. on boiling, soluble in NH_4Cl (not in KHO) and redeposited on boiling.

$HgCl_2$, Reagent:

Neutral, alkaline, or acid:

White ppt.:

Bicarbonates of K, Na, and Li: effervesce with acids.

Hypophosphites: slightly acidulated with HCl, give a white ppt. of calomel, turning dark on heating.

Reddish-brown ppt. = carbonates of K, Na, and Li; effervesce with acids.

$FeSO_4$, Reagent:

Neutral reaction:

Dark-brown ppt.:

HNO_2 and nitrites: best shown as a dark ring by contact method—disappears on heating.

HNO_3 and nitrates: in presence of H_2SO_4, dark coloration as with nitrites.

White ppt. = ferrocyanids: changes quickly to blue.

Blue ppt. = ferricyanids: ppt. insoluble in acids; deposits dirty-green Fe $(HO)_2$ when boiled with KHO.

Red = iodids.

K_4FeCy_6, Reagent:

Acid solution:

White with Ag, Hg, Pb, Sn, Zn, Mn, Cd, Bi, Sb and Ni.

White, turning light- to dark-blue, with ferrous solutions.

Dark blue with ferric solutions.

Yellowish-white with Ba.

Yellowish-green with Co.

Chocolate with Cu.

Brown with U, turning yellow on adding NH_4OH.

DETECTION AND SEPARATION OF MIXED SALTS.

If the student will bear in mind the reactions for the separate salts, he will have little difficulty in deducing methods for differentiating mixtures of salts. The following notes will serve as illustrations:—

1. To Separate Chlorids, Bromids, and Iodids.—All three give a light-colored ppt. with $AgNO_3$. This ppt., washed on a filter and percolated with dilute NH_4HO (1 to 20), will show in the percolate any chlorid by repptn. with HNO_3. The remaining deposit on the filter-paper may be treated with strong NH_4HO, which dissolves out any bromid (repptd. with HNO_3), leaving AgI as a light-yellow residue. A mere cloud on adding the acid should be disregarded.

2. To Detect Bromids in Presence of Iodids.—A blue color, produced on adding very little starch solution and a drop or two of Cl water, shows an iodid. On adding more Cl water the blue color is discharged, when, if any bromid is present, it is revealed by a yellow color on shaking with chloroform.

3. To Separate Chlorids from Chlorates.—All the chlorid is pptd. with excess of $AgNO_3$ and filtered out. The filtrate is acidulated with H_2SO_4 and a fragment or two of zinc dropped in, when if a chlorate is present it will be reduced to chlorid and give a second ppt. on adding $AgNO_3$.

4. To Separate Sulphids, Sulphites, and Sulphates.—Pour solution on excess of $CdCO_3$, digest at a gentle heat, filter, and dissolve uncombined carbonate in $HC_2H_3O_2$. A yellow residue on the paper indicates a sulphid. The filtrate may contain sulphite and sulphate, to separate which add $BaCl_2$, filter out ppt., and boil with a little HCl, which dissolves out $BaSO_3$, with evolution of SO_2 and leaves the insoluble $BaSO_4$.

5. To Separate Chlorids, Iodids, and Bromids from Nitrates.—Ag_2SO_4 ppts. the halogens and leaves the nitrate in solution.

6. To Separate Chlorids from Cyanids.—Both are pptd. by acidulating slightly with HNO_3 and adding excess of $AgNO_3$. The cyanid in the ppt., after washing thoroughly with boiling water by decantation, is dissolved in boiling HNO_3, leaving the insoluble chlorid. HCl is added to the acid solution, throwing down a white ppt.—cyanid changed to chlorid.

7. To Separate Ferrocyanids from Ferricyanids.—The ferrocyanid is pptd. with excess of $FeCl_3$, after acidulating with HCl. The supernatant brownish liquid also gives a blue ppt. when heated with a little zinc amalgam (reduction) if ferricyanid is present.

8. To Detect Cyanids in Presence of Ferrocyanids and Ferricyanids.—The latter two salts are pptd. by acidulating slightly with HNO_3 and warming gently with ferric and ferrous sulphates. When a blue color is produced in some of the supernatant liquid by adding excess of KHO and then acidulating with HCl, a cyanid is also present.

9. To Detect a Phosphate in Presence of Iron.—Dissolve in as little HCl as possible; add some $H_3C_6H_5O_7$ and then excess of NH_4HO. From this solution, when cold, magnesia mixture (1 part each of NH_4Cl, NH_4OH, and $MgSO_4$ in 8 parts of water) ppts. white crystals of NH_4MgPO_4.

10. To Detect a Phosphate in Presence of Alkaline Earths (Mg or Mn).—Dissolve in water with the aid of as little HNO_3 as possible, then add excess of $NH_4C_2H_3O_2$ to remove any excess of HNO_3; on adding a drop or two of $FeCl_3$ and warming, a white ppt. of $FePO_4$ is formed.

11. To Detect Carbolic in Presence of Salicylic Acid.—Add 1 m. each of saturated solution of $KHCO_3$, and anilin, and 5 m. of solution of chlorinated lime, when a deep blue is produced if carbolic acid is present.

12. To Separate Oxalates, Tartrates, and Citrates.—Make slightly alkaline with NH_4OH, add $CaCl_2$, allow to stand for ten minutes, and filter. Filtrate may contain citrate; on boiling gives slow, white ppt. on sides of tube. The ppt. may contain oxalate and tartrate: acetic acid dissolves the latter, not the former. The tartrate filtrate gives a white ppt. on adding NH_4OH to render slightly alkaline, and on further addition of $AgNO_3$ and boiling yields a silver mirror.

13. To Detect Nitrates in Presence of Nitrites.—Destroy the NO_2 ion by neutralizing and heating to boiling with solution of NH_4Cl, till it no longer gives the blue coloration at once when acidified and tested with KI and starch solution (NO'_2 and NH°_4 react to form N_2 and $2H_2O$)—then test for nitrate with usual reagents.

PYROLOGY.

An ordinary gas-, candle-, or spirit- flame consists of three parts, namely: an inner dark nucleus, a middle luminous cone or mantle, and an outer bluish subluminous mantle. The first portion is composed of a mixture of unoxidized gases; the second of partially oxidized gases (especially C_2H_4 and CH_4), the excess of C in solid particles reflecting the light from all points and thus making this stratum the most luminous; in the third, or outer part, which is most exposed to the O of the atmosphere, combustion is nearly complete, hence the flame is only feebly luminous.

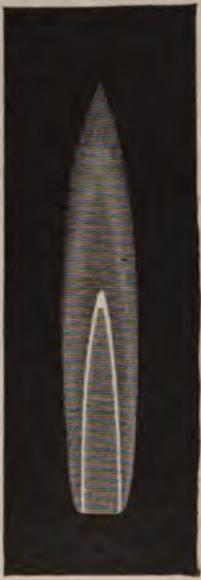

Fig. 46.—Bunsen Flame.

The Bunsen flame is hotter and less luminous than others, because air is mixed throughout the gases instead of combining merely on the surface, as in ordinary combustion. The hottest part of the Bunsen flame is the bright spot at the apex of the zone of fusion between its two mantles (about 4000° F.); hence substances to be fused should be held at this point. H burning in O furnishes 34,462 thermal units; C in O, 8080 units.

Experiment.—Close the Bunsen jet at the bottom, and by means of a small glass tube prove that the nucleus of the flame consists of unburned and combustible gases.

The blow-pipe is an instrument much used in metallurgy and analysis. It consists of a metal tube with a narrow nozzle, through which a continuous current of flame can be passed into the Bunsen flame. The blow-pipe flame has two parts: an inner bluish reducing, and an outer yellowish oxidizing; the tip of the inner cone is best for reduction. Blowing across the flame with the blow-pipe lengthens and narrows the flame, thereby increasing the sphere of combustion and the degree of heat, and concentrating the latter within narrower limits.

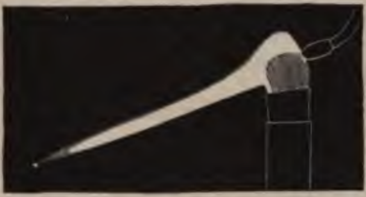

Fig. 47.—Oxidizing Blow-pipe Flame (Light Blue).

In pyrology, or analysis by fire, there are two general processes: oxidation and deoxidation (reduction). For oxidizing purposes the flame is lowered and the blow-pipe pushed into it with a fair current, in order to secure free admixture with O. The substance to be oxidized is held in the tip of the outer mantle a little beyond the apex of the luminous cone. For reducing powders to the metallic state, a stronger flame and a weaker current are employed; the blow-pipe is held just on the border of the flame, the substance to be deoxidized just within the luminous apex: *i.e.,* the part of the flame deficient in O; or the air supply may be cut off below, making the flame luminous with unburned C particles. For analytic purposes the powder is mixed with about twice as much Na_2CO_3, and the

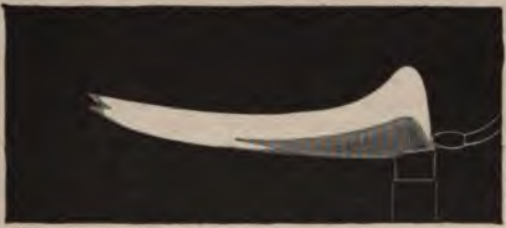

Fig. 48.—Reducing Blow-pipe Flame (Yellow).

mixture is placed in a hollow on a piece of charcoal. The carbonate reduces to oxids, reduction to the metal being completed by the carbon.

Experiment.—Oxidize powdered zinc.
Experiment.—Reduce $BiONO_3$ to metallic bismuth.

BLOW-PIPE ANALYSIS.

I. Heat on asbestos or charcoal before blow-pipe.

No residue = ordinary alkaline salts: fuse and sink into charcoal.
Residue:
  Shining white: Moisten, when cold, with a drop of $Co(NO_3)_2$ and use blow-pipe again.
    Blue = Al or borates, arsenites, phosphates or silicates.
    Green = Zn.
    Flesh color = Mg.
    Pale-rose or flesh colored = Mg.
  Colored: Use borax bead.

II. Mix with twice as much Na_2CO_3, and heat on charcoal in reducing flame.

Metallic globules or powdered mass:
  With surrounding incrustation of oxid:
    Yellow:
      Bi: brittle bead, with pink tinge, easily fusible. Heated with S and KI, yields scarlet BiOI.
      Pb: soft, gray-white, malleable; marks paper; border of white carbonate.
      Sn: white bead, very oxidizable and fusible; incrustation turns bluish-green on moistening with $Co(NO_3)_2$ and heating.
    White:
      Sb: gray, very brittle, readily oxidized and volatilized (white fumes); bead skips about when dropped, leaving a white trail; greenish-blue flame.
  No surrounding incrustation:
      Ag: clear, white malleable bead; does not oxidize readily.
      Cu: red, tough, malleable; colors flame green.
      Fe: reddish magnetic powder (Fe_3O_4).
      Co: light- or dark-blue mass, according to amount.
      Ni: violet when hot, cooling yellowish-brown.
      Mn: green mass of manganates on fusing on Pt with Na_2CO_3 and KNO_3.
      Cr: yellow mass when treated like Mn.
      Au: bright-yellow ductile bead.
      Pt: gray, infusible powder.
Only incrustation (metals volatilize) where oxidized:
  White = As: garlicky smell.
  Yellow, cooling white = Zn: may be greenish-white mass in center.
  Reddish-brown = Cd.
No globules or incrustation = Hg.
Fused masses of green or yellow color = chromates, manganates or sulphids (hepar test).
White, unfused masses = compounds of alkaline earths, Mg or Al—on heating in oxidizing flame and moistening with $Co(NO_3)_2$ solution, there result gray, flesh-colored or blue masses (also from borates, arsenates, phosphates or silicates).

VOLATILIZATION TESTS.

Mix powdered substance with a little charcoal and Na_2CO_3, place in a small dry test-tube, and heat, watching for shiny metallic mirror or sublimate on cooler part of tube.

Mercury: minute gray globules; mixture at bottom becomes red (HgO).

Arsenic: gray-black sublimate.

Antimony: similar to As, but lighter-colored.

Sulphur: yellow sublimate.

Ammonium compounds: NH_3 given off—recognized by odor and action on moist litmus-paper.

Water and hydroxids: steam.

On heating alone in a narrow bulb tube: White sublimate = NH_4 salts, As_2O_3, Sb_2O_3 or Hg salts.

Yellow sublimate = As_2S_3, Hg Compounds (HgI_2 turns red on touching with a solid) or S (reddish-brown drops).

BORAX-BEAD TESTS.

On heating sufficiently borax loses its water of crystallization, fusing into a glassy substance called a bead. Borax beads have great avidity for oxids, and with the blow-pipe give characteristic colors in the oxidizing and reducing flames for certain metals, as shown by the following short table:—

METAL.	OXIDIZING FLAME.	REDUCING FLAME.
Co	Blue.	Blue.
Cr	Green.	Green.
Cu	Green, cooling blue.	Red (cold).
Fe	Red, cooling yellowish.	Bottle-green.
Mn	Amethyst.	Colorless.
Ni	Red-brown, cooling yellow.	Gray, opaque.
Ag	Yellow.	Gray.
Ce	Red or yellow, fading on cooling.	
U	Yellow, cooling greenish.	
Mo	Green.	Green.
Wo		Blue (cold).
Ti		Violet.

Instead of borax in the colored bead tests we may employ phosphor salt, $NaNH_4HPO_4$, which on heating loses water and ammonia, yielding sodium metaphosphate, $NaPO_3$.

FLAME TESTS.

Dip loop of Pt wire in HCl (to form more volatile chlorid), then catch up a little of powder or concentrated solution and hold in outer, colorless flame near base. The following metals each give a characteristic color to the flame:—

Violet = K: look through blue glass to shut out yellow colors; NH_4 compounds and organic matter also give a faint-violet color. Through Co glass the K color appears carmine (non-luminous Bunsen flame appears blue).

Yellow = Na: color intercepted by blue glass. $K_2Cr_2O_7$ (solution or crystal) or paper painted with HgI_2 held between eye and flame appears a bright to dark yellow.

Reddish yellow = Ca.

Greenish yellow = Ba or Mo.

Green = Cu, Tl or boric or phosphoric acid.

Blue = Pb, As, Sb, Bi, $CuCl_2$.

Crimson = Li (not pptd. from solutions by NH_4 compounds) or Sr (pptd. from solution by $[NH_4]_2CO_3$ in presence of NH_4OH and NH_4Cl).

Blue-green = Te.

Sky-blue = Se (odor of horseradish).

Blue-violet = In.

Violet = Rb and Cs.

QUANTITATIVE ANALYSIS.

Quantitative determinations are, in general, either gravimetric or volumetric. Gravimetric methods consist simply in drying and weighing the various ppts. obtained separately as described heretofore. Precipitation should be complete, as shown by the reagent giving no further ppt. after subsidence. Knowing the chemic composition of the ppt., the amount of each element in it and the weight of the original substance in solution are readily calculated (see "Stoechiometry"). The amount of substance taken to be analyzed, if in the solid state, should rarely exceed a gram.

All the ppt. (usually best obtained in a beaker, avoiding excess of reagent) is collected by filtration on a small circle of filter-paper (Swedish No. 2 is best), is well washed with distilled water, and then dried by placing filter and contents in a drying oven at 100° C. The dry powder, if inorganic, is then transferred from the paper to a tared crucible, the folded paper (containing particles of ppt.) is incinerated on the lid of the crucible over the flame, and the ash is removed to the crucible, which is now heated until all moisture is expelled. After cooling in a desiccator (a closed vessel containing a dish of H_2SO_4), the crucible and its contents are weighed, and the weight of the crucible alone and of the filter-ash (previously determined by weighing others, or stated on each package) deducted. Organic ppts. generally and some inorganic, like K_2PtCl_6, are collected on a previously dried and weighed filter, well washed, dried at 100°, then weighed; the weighing each time is best done between two watch-crystals held together by clamps. The addition of a few crystals of NH_4NO_3 to the substance in a crucible aids and hastens the process of incineration.

It should be borne in mind that ignition often changes the character of a ppt.; thus, oxalates become carbonates; hydroxids, oxids; and phosphates, pyrophosphates. The water of crystallization is estimated by heating a gram or so of the salt in the air-bath at from 120° to 300° until no further loss in weight takes place. The carbonic acid of carbonates is generally determined by treating with dilute HCl, and calculating the loss as CO_2. In heating substances which foam, to determine ash, loss by running over can be prevented by inverting the Bunsen burner over the specimen until it is charred.

In the wet methods of quantitative analysis it is particularly necessary to throw down all of a given compound by adding the reagent drop by drop to the solution, with shaking or stirring and sometimes warming, until no further ppt. is produced. After this the mixture should stand for a few minutes to allow complete precipitation to take place. The ppt. on the filter should be well washed, as a rule, by means of a jet of distilled water from the wash-bottle, saving the washings with the remainder of the filtrate for the next reagent. Cloudy washings can usually be prevented by allowing the deposit on the filter to drain dry before washing. Filtration is aided by conducting the clear supernatant liquid down a glass rod from the lip of the beaker on to the filter before washing the ppt. out of the beaker.

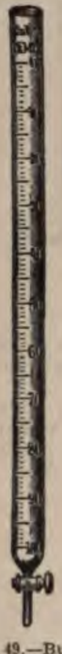

Fig. 49.—Buret.

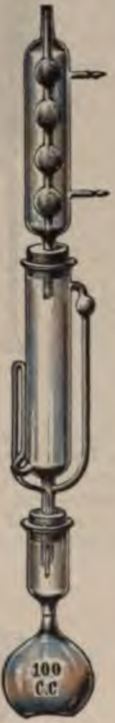

Fig. 50.—Extraction Apparatus.

In the use of the analytic balance and weights care should be taken never to put any chemical directly on the pan, but in a clean tared crucible or watch-crystal; to use forceps, not fingers, for lifting weights; to keep the beam off the knife-edges when making any transfer; to weigh corrosive substances in stoppered tubes; and to keep dust out of the instrument as much as possible. Careful notes should be taken of each step and a systematic record kept for final calculation and future reference.

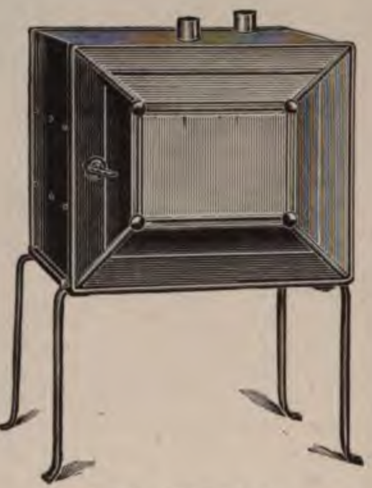

Fig. 51.—Drying Bath.

Experiment.—Weigh out 1 gm. of $BaCl_2.2H_2O$, dissolve in 100 c.c. of water, ppt. Ba with dilute H_2SO_4, dry and weigh ppt., and reckon from this weight that of the chlorid first taken.

Experiment.—Ppt. Pt from solution of $PtCl_4$ by adding NH_4Cl, then one-half volume of alcohol. Collect ppt., wash with alcohol, dry and weigh. Every 100 parts of the ppt. represent 44.28 parts of Pt. Why?

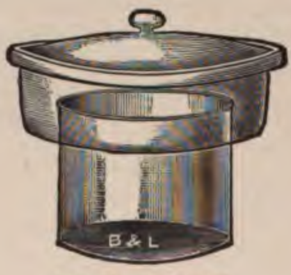

Fig. 52.—Desiccator.

Fats and oils are separated from other constituents of a substance by continuous extraction for some hours with boiling ether, petroleum ether or CCl_4 in the Soxhlet or some similar apparatus provided with a condenser at the top. The material to be extracted is placed in a fat-free paper thimble covered with a plug of cotton, in a glass tube loosely plugged at each end, or in a Gooch crucible.

Crude fiber in vegetable matter (fat-freed) can be determined by boiling for a half-hour with 1.25 per cent. H_2SO_4 and 1.25 per cent. NaHO solution successively. A simple arrangement to overcome foaming is a beaker on which rests a hemispheric glass evaporating dish nearly filled with cold water. If material is carried up side of beaker, dislodge and bring down with rubber-tipped glass rod.

The volumetric method is very rapid and convenient, and consists essentially in adding to a substance in solution from a buret (titration) a standard solution of the reagent until the reaction is just completed, as shown by color-changes in the substance tested or in some other substance added as an indicator. Graduated flasks or beakers and pipets are also utilized in this method.

Standard solutions are either normal or empiric: that is, arbitrary, as Fehling's solution, which is so constituted that 1 c.c. is completely reduced by 5 mg. of dextrose.

All normal solutions are chemically equivalent to each other in equal volumes. They are prepared by dissolving in a liter of distilled water the weight in grams of a molecule (gram-molecule) of the substance (including water of crystallization) in the case of monovalent substances (monacid or monobasic); one-half the gram-molecule in the case of substances combining in the divalent rôle [H_2SO_4, Na_2CO_3, $Ca(HO)_2$]; and one-third the gram-molecule of substances whose hydrogen equivalence of the positive and the negative ions is 3. By the standard or titer of a volumetric test solution is meant its strength per liter or cubic centimeter. A normal solution is expressed briefly as $N/_1$ or M. More delicate results are obtained by diluting normal solutions 10 to 100 times, the resulting solutions being designated as $N/_{10}$ (decinormal) or $N/_{100}$ (centinormal).

Volumetric methods are of three general types: direct, indirect, and residue. The neutralization of an acid with an alkali is an example of the first; the liberation of Cl from HCl by boiling with MnO_2 and the estimation of the Cl with KI as liberated I by means of $Na_2S_2O_3$ is an example of the second; the estimation of $CaCO_3$ by difference on treating with a normal acid solution, which is afterward titrated with alkali to determine the loss of acidity, is an example of the third class.

The chief general processes included under volumetric titration are neutralization (acidimetry and alkalimetry), oxidation (dichromates, permanganates), reduction (ferrous salts, $H_2C_2O_4$), precipitation, and iodimetry (estimation of I with $Na_2S_2O_3$).

The principal color-changes are in litmus (from red to blue for neutralization of acids, and *vice versâ*), phenolphthalein (1 per cent. solution in dilute alcohol: pink with alkalies, colorless with acids—does not redden with bicarbonates), cochineal or rosolic acid (yellow with acids, violet with alkalies; used chiefly for NH_3 and NH_4 compounds), methyl-orange (0.1 per cent. aqueous solution: yellow with hydrates, carbonates, and bicarbonates; orange-red with acids), starch solution (blue with I), K_2CrO_4 (red color with Ag salts), and ferric alum (brown-red with KSCN). Phenolphthalein is itself slightly acidic. It is not a suitable reagent with NH_3 or bicarbonates. Methyl-orange (red) is converted by bases into the dissociated salt (anion, yellow).

A few drops of these solutions are added to the substance to be tested, also in solution in a beaker or flask. $KMnO_4$ gives off O, and is decolorized on heating with organic substances in an acid solution. CrO_3, on reduction, changes from orange to green.

Weak acids (carbonic, phosphoric) should be titrated with litmus and a strong base. Weak bases (NH_3) should be titrated with a strongly acidic indicator (methyl-orange) and a strong acid.

The basis for normal acid solutions is oxalic acid, which is chosen because it does not contain a variable quantity of non-crystalline water, as is the case with the common mineral acids. The full formula of crystallized oxalic acid is $H_2C_2O_4.-.2H_2O$; hence the molecular weight is 125.7. Being dibasic, one-half this weight, or 62.85 gm. of the acid, is dissolved in sufficient distilled water at 15° to make a liter.

The basis for normal alkali solutions is Na_2CO_3, of which 52.92 gm., or half the gram-molecule, is dissolved in water and diluted to a liter. Other normal alkali solutions (KHO, NaHO) are obtained by dissolving approximately the H equivalence (one-half or the full molecular weight in grams) of the substance in about 1000 c.c. of water, then titrating with normal acid and diluting with water until 10 c.c. of the acid solution is exactly neutralized by 10 c.c. of the alkali. Other normal acid solutions than oxalic are standardized by means of a normal alkali solution.

In titrating carbonates with normal acid, the alkaline solution should be boiled toward the end of the reaction in order to drive off CO_2, which has an acid reaction on litmus and phenolphthalein, but not on methyl-orange. Alkali salts of the organic acids are first converted into carbonates by ignition before titrating with acids.

Acids neutralize bases (including oxids, carbonates, and organic salts after ignition), and bases neutralize acids or acid salts (such as KH_2PO_4). For example:—

$$\overset{39.96}{NaHO} + \overset{36.37}{HCl} = \overset{58.37}{NaCl} + \overset{17.96}{H_2O}$$

As shown by the molecular weights with the above equation, 1 c.c. of any normal solution is equivalent to 1 c.c. of any other for which it is a test, and the exact weight of any acid or alkali in solution is readily found by neutralizing with a normal or decinormal alkali or acid, and multiplying the number of c.c. used of the latter by the weight in mg. of 1 c.c. of a normal solution of the substance tested. The following table of common neutralization equivalents in grams is convenient for reference:—

One C.C. of Normal Acid is Equivalent to		One C.C. of Normal Alkali is Equivalent to	
Ammonia	0.01701	Acetic acid	0.05986
Ammonium carb. (U.S.P.)	0.05226	Citric acid	0.06983
Lead subacetate	0.13662	Hydrobromic acid	0.08076
Lithium carbonate	0.03693	Hydrochloric acid	0.03637
Potassium bicarbonate	0.09988	Hydriodic acid	0.12753
Potassium carbonate	0.06895	Hypophosphorous acid	0.06588
Potassium hydroxid	0.05599	Lactic acid	0.08989
Potassium permang.	0.03153	Nitric acid	0.06289
Pot. sodium tartrate	0.14075	Oxalic acid	0.06285
Sodium bicarbonate	0.08385	Phosphoric acid (K_2HPO_4)	0.04890
Sodium borate	0.19046	" " (KH_2PO_4)	0.09780
Sodium carbonate	0.05292	Potassium dichromate	0.14689
Sodium hydroxid	0.03996	Sulphuric acid	0.04891
Strontium lactate	0.13244	Tartaric acid	0.07482

The pharmaceutic practice of volumetric work is to weigh out such an amount of the substance for analysis that the number of c.c. of the normal solution used will express the percentage. Thus, 3.62 gm. of United States Pharmacopeia dilute HCl containing 10 per cent. of the anhydrous acid is exactly neutralized by 10 c.c. of normal alkali.

Alkaloids can be estimated volumetrically by dissolving in a measured amount of $N/_{20}$ HCl and determining the excess of acid over that which combines with the alkaloid, by means of $N/_{20}$ NaHO, using phenolphthalein as an indicator. Each c.c. of the $N/_{20}$ acid is equivalent to the following gram factors of alkaloids:—

Aconitin	0.0323	Coniin	0.0062
Atropin	0.0144	Morphin	0.0142
Brucin	0.0197	Nicotin	0.0040
Cinchonin	0.0147	Quinin	0.0162
Cocain	0.0151	Spartein	0.0028
Codein	0.0149	Strychnin	0.0167

Mayer's solution, or the decinormal potassium mercuric iodid solution, contains 39.2 gm. of this salt per liter, and is made by dissolving 13.546 gm. of $HgCl_2$ in 600 c.c. water and 49.8 gm. KI in 100 c.c. water, mixing the two solutions and diluting up to 1000 c.c. This solution is used in estimating some of the alkaloids, which should be distinctly acidified (not with $HC_2H_3O_2$) before running in the reagent. The end of the reaction is shown when the reagent produces a ppt. with a few drops of clear filtrate; an excess should be avoided. The ppts. formed by Mayer's reagent are compounds of the base with one or more molecules of HI and HgI_2. The following equivalents have been determined experimentally for each c.c. of the decinormal solution:—

Aconitin	0.0269	**Morphin**	0.0200
Atropin	0.0097	**Narcotin**	0.0213
Berberin	0.0425	**Nicotin**	0.0040
Brucin	0.0197	**Physostigmin**	0.0137
Cinchonin	0.0102	**Quinidin**	0.0120
Coniin	0.0125	**Quinin**	0.0108
Emetin	0.0189	**Strychnin**	0.0167
Hyoscyamin	0.0069	**Veratrin**	0.0296

Oxidimetry is accomplished by means of potassium permanganate, $KMnO_4$ (313.96), which gives off 5 atoms of O in the presence of H_2SO_4 and organic matter:—

$$2KMnO_4 + 3H_2SO_4 = K_2SO_4 + 2MnSO_4 + 5O + 3H_2O$$

A normal oxidizing solution is one which will liberate as much O per liter as is equivalent to 1 gram-atom of H, namely: ½ gram-atom, or 8 gm. of O, since it takes 2 of H to combine with 1 of O. A normal solution of $KMnO_4$ therefore contains $\frac{1}{10}$ its molecular weight ($\frac{1}{2} \div 5$), or 31.396 gm. per liter. It is standardized by means of normal (or decinormal) oxalic-acid solution, equal volumes of which completely decolorize the permanganate solution. The equivalence of normal $KMnO_4$ for different substances is obtained by studying the equations representing their reactions. For example: $KNO_2 + O = KNO_3$. Nitrites take up 1 atom of O, equivalent to 2 liters of $N/_1$ $KMnO_4$ $\therefore$ the equivalent factor of:—

$$KNO_2 = \frac{39.03+14.01+31.92}{2 \times 1000} = \frac{84.96}{2000} = 0.04248$$

The decinormal equivalent is 0.004248. In estimating Fe and its compounds with $KMnO_4$, ferric compounds must first be reduced to ferrous by heating in a flask with nascent H ($Zn + H_2SO_4$).

The following are the most important equivalences of 1 c.c. of decinormal $KMnO_4$:—

Barium dioxid	0.008441	**Hydrogen dioxid**	0.001688
Ethyl nitrite	0.003743	**Hypophosphorous acid**	0.001647
Ferrous carbonate	0.011505	**Oxalic acid (cryst.)**	0.006255
Ferrous oxid	0.007195	**Oxygen**	0.000794
Ferrous sulphate	0.015085	**Potassium hypophosphite**	0.002598
Ferrous sulphate (cryst.)	0.027601	**Sodium hypophosphite**	0.002646

Iodimetry depends on the decolorizing reaction between I and $Na_2S_2O_3$:—

$$2I + 2Na_2S_2O_3 = 2NaI + Na_2S_4O_6$$

Normal solutions of both these substances are used with starch solution (1 gm. of starch in 200 c.c. of boiling water) as an indicator of uncombined I. The thiosulphate is also employed for the volumetric determination of Cl and of ferric salts through the agency of KI, free I being liberated. Decinormal I solution is made by dissolving 12.653 gm. of I in a solution of 18 gm. of KI in 300 c.c. of H_2O and diluting to a liter. Sodium thiosulphate contains 5 molecules of water of crystallization; hence its normal solution is made to contain 246.46 gm. of the salt per liter.

Decinormal $AgNO_3$ solution (16.869 gm. per liter) is used for the direct estimation of haloid salts and acids. Normal K_2CrO_4 is used as an indicator, forming permanent red chromate of silver as soon as all the chlorid, bromid, and iodid has been pptd.

Copper is generally estimated volumetrically by a standard solution of KCN, made by dissolving 60 gm. of KCN in a liter of water, the solution to be kept in a dark place in a glass-stoppered bottle. Then weigh out 0.25 gm. of pure Cu foil or wire, place in a beaker, and add 10 c.c. each of HNO_3 and H_2O, and boil till all the Cu is dissolved and brown fumes cease to appear. Transfer the solution and beaker washings to a 100 c.c. flask, dilute to the mark, and shake thoroughly. Take half of this in a beaker, add slight excess of NH_4OH and run in the KCN solution until the blue color is changed to a faint pink. Repeat the standardizing process with the other half of the Cu solution, and take the average of the two findings. Compute the equivalence factor by dividing 0.125 by the number of c.c. of KCN used to decolorize the Cu solution. Thus, if it takes 20 c.c. of KCN to remove the blue color, then the factor is:—

$$0.125 \div 20 = 0.00625$$

HCN is estimated by treating solution with 5 c.c. strong NH_4OH and 2 c.c. 5 per cent. KI, then titrating with $n/_{10}$ $AgNO_3$ until a permanent cloudiness appears. Each c.c. of silver solution equals 0.005396 gm. HCN.

SPECIAL METHODS AND APPARATUS.

ARSENIC TESTS.

If dissolved in stomach-contents, separate from colloids by dialysis, and destroy all organic matters by boiling for some hours with addition of HNO_3, and filtering. The chemicals and dishes used must first be proved free of arsenic by blank tests.

1. Ignite on charcoal with blow-pipe and note garlicky odor.

2. Heat a small quantity in a reduction tube with Na_2CO_3 and KCN; observe dark metallic mirror in upper part of tube, due to As. On breaking off lower end of tube and heating again, we get a crystalline mirror of As_2O_3.

3. **Fleitmann's Test.**—Boil a small piece of Al with KHO:—

$$Al_2 + 2KHO + 2H_2O = K_2Al_2O_4 + 3H_2$$

In presence of As H_3As is formed, reducing $AgNO_3$ (white filter-paper dipped in strong solution and held over mouth of tube) to black, shining, metallic Ag. Sb does not react to this test at all.

4. **Reinsch's Test.**—The arsenic solution acidulated with one-seventh as much HCl deposits a blue-gray film of As (or Sb, Hg, Ag or Bi and some rare metals) on Cu foil with the aid of heat. Wash foil in water, dry with filter-paper, and heat gently in wide, dry test-tube or near lower end of open glass tube about 3 mm. in caliber. Note crystalline deposit in upper part of tube. Break tube and examine crystals of As_2O_3 under microscope. They are octahedral—rhombic prisms if cooled rapidly. A film of Sb_2O_3 yields a white band of amorphous (rarely octahedral) material. Bi gives no sublimate on heating in a glass tube. Hg shows a sublimate of minute shining globules.

Test Cu for Reinsch's test by polishing it, then drop a portion into a boiling mixture of equal parts of solution of $FeCl_3$ and conc. HCl. If As is present in the copper, it will show as a black coating. The Reinsch test acts only with strong solutions of arsenic acid. It is interfered with by oxidizing agents, which dissolve Cu.

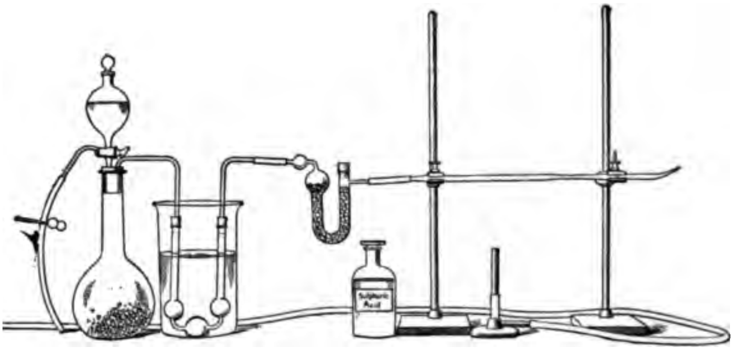

Fig. 53.—Apparatus for Detection of Minute Amount of Arsenic.

5. **Marsh's Test.**—Prepare nascent H from pure Zn and dilute H_2SO_4; after a few minutes ignite and show that no stain is produced by the flame on a white porcelain surface. Then add suspected solution. If As is present, the color of the flame changes to a light blue (As_2O_3 fumes) characteristic of H_3As, and a dark metallic stain is left on a white porcelain surface by touching it to the flame. This stain may be either metallic As or Sb. To distinguish between the two (As is soluble in NaClO solution) dissolve the spot in a drop of HNO_3, evaporate gently (As is volatile), and apply a drop of a strong solution of $AgNO_3$, which gives with As a brick-red mark due to Ag_3AsO_4; the stain exposed to H_2S turns lemon-yellow. The tube through which the H_3As passes, when heated to a dull-red heat, shows a mirror, in the cooler part, of metallic As. Extinguish the flame and dip delivery tube into $AgNO_3$; on running NH_4HO over the latter fluid a yellow ring appears at the junction of the two fluids. Marsh's is the most delicate test known for As and its compounds, showing, it is said, as small a proportion as 1 part in 200,000,000. Unfortunately it is inconclusive in the presence of organic matter, which can, however, be destroyed by oxidizing with HNO_3 or with $KClO_3$ and HCl.

The Marsh test is interfered with by chlorids, nitrous compounds, HCl, HNO_3 and salts of Ag or Hg. The gas passed into $AgNO_3$ solution gives a black deposit of Ag_3Sb (As stays in solution). $CaCl_2$ should be placed in a drying tube between plugs of glass-wool. Heat the hard glass exit tube red-hot for 15 minutes to test purity of chemicals. If organic matter causes much frothing, add a little alcohol.

To detect the presence of arsenic in wall-paper, oxidize to arsenic acid and destroy organic matter by warming with HNO_3 and H_2SO_4. Evaporate excess of acid, dilute with water and apply Marsh's test.

6. Gutzeit's Test.—Put about 1 gm. pure Zn in a test-tube, add 5 c.c. of 5 per cent. H_2SO_4 and a few drops of the As solution (not alkaline). Cap the mouth of the tube with three thicknesses of white filter-paper, and moisten the upper paper with a drop of saturated aqueous solution of $AgNO_3$ acidulated with 1 per cent. of HNO_3. Place tube in box away from light. After some hours, or sooner, a yellow stain, $Ag_3As(AgNO_3)_3$, appears on the paper cap, turning brown or black on moistening with H_2O. Compounds of Sb yield a dark stain with this test, but no previous yellow color. This test shows as little as 0.001 mg. As_2O_3.

The Fungus Test.—The "arsenic fungus," Penicilium brevicaule, is said to yield the odor of garlic on contact with even 0.01 mg. As.

ZINC TEST FOR ANTIMONY (HOLLAND).

Put suspected liquid in a Pt dish and acidify with HCl. On immersing a strip of pure Zn, Sb (not As) is deposited on the Pt as a black stain. Wet stain with HNO_3, dry at a gentle heat and touch with a drop of dilute $(NH_4)_2S$, getting an orange-red color.

MacCALLUM'S TEST FOR IRON.

A small quantity of 0.5 to 1 per cent. solution of hematoxylin added to an iron compound produces a blue-black reaction with inorganic —no color with organic iron.

MERCURY.

Galvanic Test.—Place on a Cu coin a drop of suspected solution, acidulate with HCl, and touch coin at this spot with a knife-blade. Hg is deposited as a silvery film of amalgam.

A similar test is made by wrapping spirally a strip of dentist's gold foil around a bar of Zn, and immersing the couple in the suspected solution acidulated with HCl. The Au becomes covered with a silvery film, and on heating in a glass tube yields a sublimate of minute highly refractive globules.

Free I, left in a sublimation tube a few hours, turns Hg film-ring yellow, then red.

COPPER.

A knife-blade or other piece of bright metal dipped into an acidulated solution shows a red deposit of metallic Cu. The Cu film on Fe turns blue on dipping in NH_4OH and exposing to the air.

Ammonia added to solutions containing Cu gives a blue color when enough has been added to neutralize any acid present.

Galvanic Test for Copper.—Make a galvanic couple by wrapping Pt wire around Zn foil. Pt is discolored by Cu, and on exposing to vapors arising from KBr treated with H_2SO_4, the deposit changes in color and leaves a violet mark on white porcelain.

PALLADIUM.

$Hg(CN)_2$ ppts. light-yellow cyanid, soluble in HCl and easily reduced to the metal by heating.

MAGNESIUM.

Compounds are soluble in water or dilute HCl. $(NH_4)_2CO_3$ does not ppt. if NH_4Cl has been added first, but on treating also with Na_2HPO_4 there falls a feathery, white ppt.

HYDROCYANIC ACID.

Liebig's Test.—Place a portion of the liquid in a porcelain capsule; add a few drops of a dilute solution of NaHO and a few drops of solution of yellow NH_4HS. Evaporate to dryness on water-bath; then add a little water and acidulate with HCl. Finally add 2 or 3 drops of solution of $FeCl_3$. A fine red color proves presence of HCN. This is the most delicate of all the tests for prussic acid, giving a distinct reaction with a solution of 1 to 4,000,000.

PHOSPHORUS.

Simon's Test.—To detect minute amounts (1 part in 100,000) of phosphorus in cases of poisoning render the matter to be examined fluid by the addition of water, slightly acidulate with H_2SO_4, and place in a flask which is connected with a bent glass tube leading to a Liebig condenser. Place the apparatus in the dark and heat the flask, raising the temperature gradually to the b.p. If P be present, a luminous ring is seen where the glass tube leading from the flask enters the condenser. H_3PO_3 or small globules of P may be found in the fluid collected in a glass vessel. Vapors of alcohol, Cl, NH_3, H_2S, I, ether or essential oils and chlorids of Hg diminish or prevent the luminosity of P vapors.

A filter-paper dipped in $AgNO_3$ and held over mouth of apparatus turns black (reduced to metallic Ag—unoxidized P gives black Ag_3P).

Phosphin Test.—It burns with a green color when evolved with H (Zn and dilute H_2SO_4), and free P (vaporized) glows spontaneously in the dark at the jet without lighting. This test reacts to P, phosphids, phosphites and hypophosphites. After death P may be converted into NH_4MgPO_4 or some other salt of no medico-legal significance.

PHENOL.

Dragendorff's Test.—To 50 c.c. of H_2O add 3 drops of anilin, and dilute 10 drops of the mixture with 10 c.c. of water. Add as much NaClO solution as is needed to change the blue color first formed to a brown, let stand a few minutes and add suspected solution, previously treated with a few drops of NH_4OH. A permanent blue color proves presence of phenol.

MORPHIN.

Pellagri's Test.—Treat with HCl containing a little H_2SO_4, and heat moderately. Let cool and mix residue with a drop of HCl and then with slight excess of $NaHCO_3$. Add a little water and then a drop or two of weak solution of I in alcohol. If morphin is present, a green color is produced. Ethereal sulphates (formed before and after death) and aromatic tyrosin derivatives show color reactions closely resembling those given by morphin, particularly when amyl alcohol has been used for extraction.

Lefort's Test.—Add to suspected fragment in porcelain dish or on dried strips of filter-paper, a drop of solution of iodic acid and leave for 10 minutes, then add a drop of 10 per cent. NH_4OH. A mahogany color shows morphin. If free I appears from the iodic acid, wash the spot with $CHCl_3$ before adding the ammonia. Equal parts of H_2SO_4 and formalin turn morphin purple or violet, fading very slowly.

Volumetric Estimation of Morphin in Solution.—Add 5 c.c. of the solution to 10 c.c. of decinormal solution of I in KI, dilute with 35 c.c.

PLATE II.

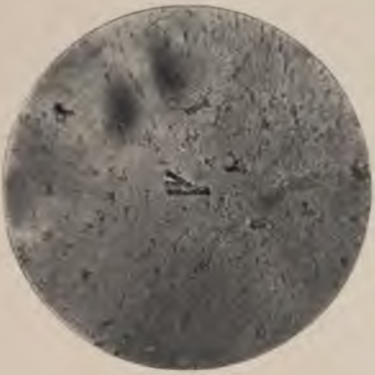

Fig. 1

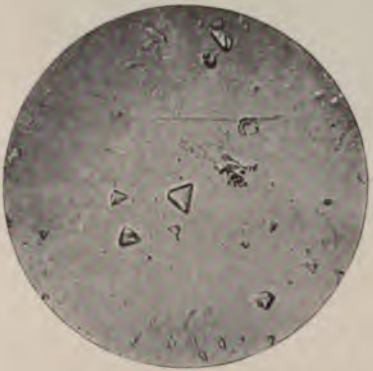

Fig. 2

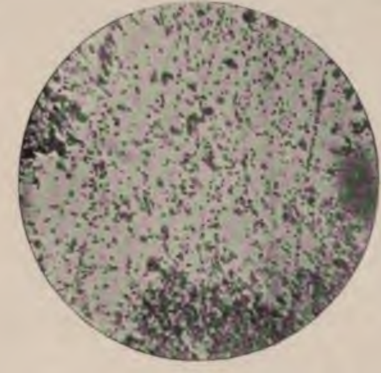

Fig. 3

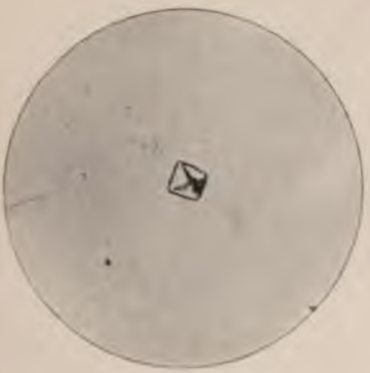

Fig. 4

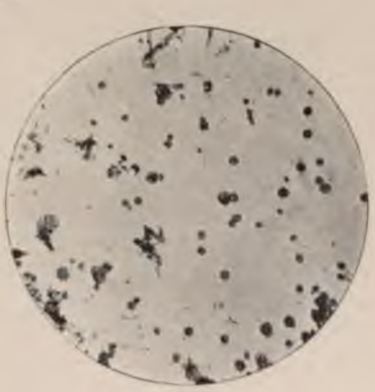

Fig. 5

INORGANIC POISONS.

H_2O and shake until supernatant liquid is quite clear. Filter off half the volume and titrate with a standard solution of thiosulphate to estimate the free I. The weight of I consumed in pptg. the alkaloid times $0.74918 \times 2 =$ weight of anhydrous morphin in original solution. Morphin has 1 molecule of water of crystallization; the sulphate, 5 molecules.

ACONITIN.

Numbness and tingling of lips and tongue in a few minutes after holding in mouth for a minute *(very poisonous)*. $AuCl_3$ gives a yellow amorphous ppt., which can be crystallized from alcohol. When in considerable quantity, says Prescott, moisten residue with HNO_3, evaporate to dryness, cool and add a drop or two of alcoholic solution of KOH, getting odor of ethyl benzoate.

TEXTILE FIBERS.

Peltier's Test.—Immerse the fibers for 15 minutes in a mixture of equal volumes of H_2SO_4 and HNO_3, then wash thoroughly in water. Silk is completely dissolved, wool is colored yellow or light brown, while vegetable fibers are unchanged in color or structure, but yield highly combustible gun-cotton when dried.

ANALYSIS OF GASES.

Gases, driven off by heat or otherwise, are measured in graduated glass tubes (eudiometers), usually over mercury, sometimes over brine or water. The weight is calculated from the volume, making due allowance for temperature and pressure, according to the rules laid down in the section on "Physics." A mixture of O, N and CO_2 in the eudiometer is analyzed by exposing the gases, first over a solution of KHO (removes CO_2), then introducing a piece of P (absorbs O), the N remaining.

ELECTROLYTIC METHODS.

These are very convenient for separating small quantities of mineral poisons from organic fluids—after oxidizing with $KClO_3$ and HCl. Mann employs a small glass vessel with a bottom of parchment-paper, immersed to the surface-level in an outer vessel containing distilled water acidulated with H_2SO_4. The cathode (about 50 cm. square) of a battery of four Grove cells is made of gold foil for Hg, of Pt for Pb, and is fixed in the inner vessel near to and parallel with the bottom. The anode (Pt for Hg) is set in the outer liquid near to and parallel with the cathode. The current is passed for six hours, when the cathode is removed, thoroughly washed, and freed from the coating metal by sublimation or the use of solvents. For Cu a Pt dish (cathode) and Pt foil (anode) may be used, passing a weak current through the fluid until it is decolorized, but turns blue when a drop of it is brought in contact with NH_4HO. One faraday of 96,000 coulombs is required to deposit one gram-equivalent of any substance.

MICROCHEMIC TESTS.

These are very delicate and attractive. The solution tested should seldom be above 0.01 per cent. in strength, and a small drop of this and of the reagent is sufficient. It is often well to mix the solutions warm and allow them to cool slowly on a slide. A polarizing apparatus and a goniometer add to the interest of the work.

Aconitin.—Two crystalline isomeric aurochlorids are prepared by admixture with $AuCl_3$.

Ammonium.—On adding NaHO, Na_2HPO_4, and $MgSO_4$, characteristic rhombic, feathery crystals of NH_4MgPO_4 are formed.

Arsenic.—As_2O_3, when heated in a narrow tube with access of air, forms in the cooler part a sublimate of characteristic colorless octahedra (tetrahedra or dodecahedra), having a somewhat triangular outline.

Atropin.—A dilute solution of sulphate yields with picric acid a copious light-yellow deposit, which, after stirring, soon becomes crystalline, and appears under the object-glass as aggregations of rhombic, transparent plates.

A saturated solution of Br in HBr yields a yellow ppt., quickly forming lozenge-shaped crystals, insoluble in acetic acid.

Barium.—Ammonium fluosilicate ppts. Ba compounds from slightly acid solutions as $BaSiF_6$, which occurs in needles and rods.

Calcium.—The addition of a soluble sulphate to a Ca solution ppts. colorless, acicular crystals, often arranged in radiate masses or sheaves. Alcohol-vapors render the reaction more sensitive.

Cocain.—Free cocain crystallizes in monoclinic prisms, melting at body temperature. Add a drop of dilute $KMnO_4$ to a drop of the cocain solution, getting bright violet rhombic plates. Cocain hydrochlorid is immediately pptd. by $AuCl_3$, showing ragged, acicular, stellate crystals (obtained in solutions of 1: 12,000 and stronger).

Coniin.—Touched with alloxan, it gives a deep purple-red color and white acicular crystals, which turn purple on adding KOH.

Corrosive Sublimate.—A very small quantity heated in a reduction-tube volatilizes unchanged and recondenses as feathery or snowflake crystals which turn red on sliding a drop of KI under the cover-glass.

Homatropin, 0.005 gm., dissolved in 10 c.c. of boiling acidulated (HCl) water, yields with 5 per cent. $AuCl_3$ on cooling large, short prisms, with pointed ends.

Hydrocyanic Acid.—Place dilute solution of acid in a watch-glass, and over this invert another glass holding to its surface a small drop of $AgNO_3$ solution. The acid vapor (driven off more rapidly by warmth of hand) forms a white film of AgCN, which appears under the microscope as very small, irregular, prismatic crystals (vapors of Cl, Br, and I yield amorphous deposits).

Hyoscyin and hyoscyamin yield with $AuCl_3$ long, flat needles or irregular plates, respectively. Atropin chloraurate is granular in appearance.

Lead.—A very small quantity ($\frac{1}{250}$ grain) in solution yields with KI a yellow ppt., which, after heating to boiling, separates on cooling in golden-yellow six-sided plates.

Lithium.—Na_2HPO_4 added to a hot neutral solution of a Li salt causes rectangular crystals of Li_2HPO_4 to separate.

Magnesium.—Add NH_4Cl, heat to boiling, then add a warm solution of Na_2HPO_4 rendered alkaline with NH_4OH, and note fern-like crystals of NH_4MgPO_4.

Morphin.—One one-hundredth grain of salt dissolved in 1 m. of H_2O yields with a small drop of KI, on stirring and standing, a white, crystalline ppt. consisting of radiate bundles of fine needles.

PLATE III.

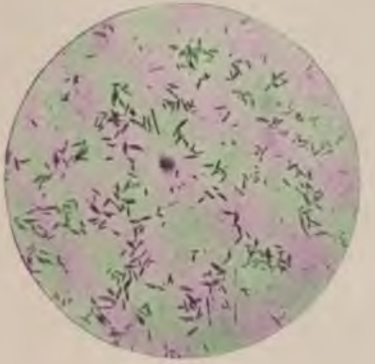

Fig. 1

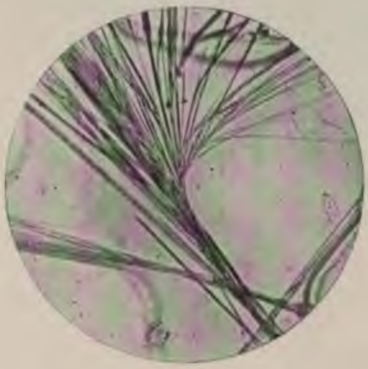

Fig. 2

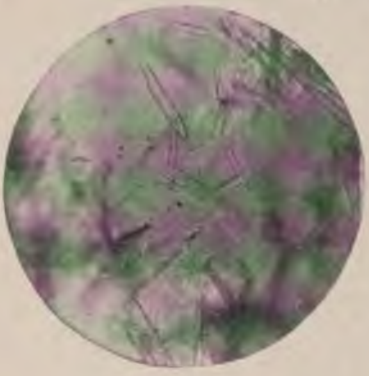

Fig. 3

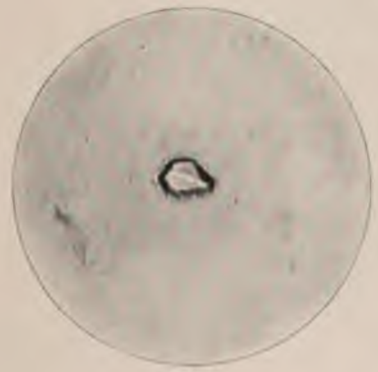

Fig. 4

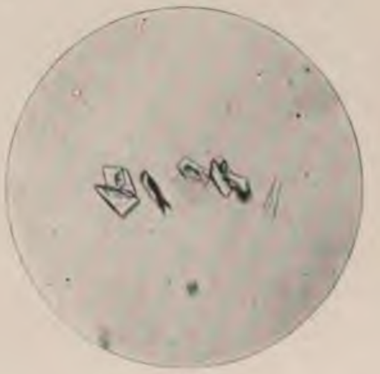

Fig. 5

ORGANIC POISONS.

Muscarin.—This alkaloid is usually obtained as a syrup, freely soluble in water and alcohol, and very strongly alkaline. Excess of $PtCl_4$, on evaporation in a vacuum, yields small octahedra.

Nicotin.—$HgCl_2$ yields white crystals, soon turning yellow, soluble in $HC_2H_3O_2$ or in HCl. Ethereal solution of I gives a ppt. of ruby-red crystals (Roussin's test).

Oxalic Acid.—$CaCl_2$ yields octahedra, small and colorless; microscopic appearance like back of square envelope. ZnC_2O_4 is similar in structure.

Potassium.—Neutral or slightly acid solutions, evaporated slowly after adding $PtCl_4$, exhibit highly-refractive, yellow octahedra of K_2PtCl_6. Alcohol makes the test more sensitive.

Quinin.—Stellar groups of needles quickly appear on adding 0.5 c.c. of 5 per cent. K_2CrO_4 to 5 c.c. of saturated aqueous solution of sulphate.

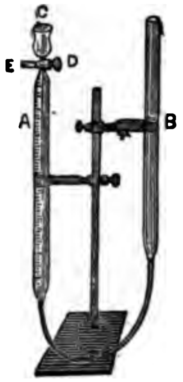

Fig. 54.—Nitrometer.

Sodium.—Acetate of uranyl causes, in concentrated Na solutions, the formation of tetrahedra and allied forms of $NaC_2H_3O_2$, $UO_2(C_2H_3O_2)_2$.

Strontium.—Chromates ppt. $SrCrO_4$ in presence of $NaC_2H_3O_2$: yellow rods, spheres, and dumb-bells.

Strychnin.—One one-hundredth grain or less dissolved in 1 m. of H_2O and treated with KCNS, yields a white, crystalline ppt., consisting of long, radiating prisms and club-shaped forms.

NITROMETRY.

The nitrometer is an instrument consisting of two upright glass tubes (one open above, the other graduated and provided with a stop-cock) connected below with rubber tubing. It is used especially for the determination of the strength of spirit of nitrous ether.

Estimation of Ethyl Nitrite.—According to the United States Pharmacopeia (1890) if 5 c.c. of recently prepared spirit of nitrous ether be introduced into a nitrometer and followed by 10 c.c. of KI and then 10 c.c. of H_2SO_4, the volume of NO generated at 25° C. should not be less than 55 c.c. (corresponding to 4 per cent. of pure ethyl nitrite). The instrument is commonly filled with a strong common-salt solution, which does not absorb NO. To take the reading the surface of the liquid in the two tubes should be at a level with each other:—

$$C_2H_5NO_2 + KI + H_2SO_4 = C_2H_5HO + I + KHSO_4 + NO$$

Estimation of Strength of Bleaching Powder.—Weigh out 0.5 gm. of the powder, rub with water to a thin paste, pour into a liter flask, and dilute to the mark. Shake well, and place 50 c.c. of the turbid solution in the nitrometer, and fill with water; then admit 5 c.c. of H_2O_2 (rendered just alkaline with NaHO) from little cup, and let stand until gas formation ceases. The volume of O evolved represents the same volume of active Cl.

Estimation of O in H_2O_2.—Since $5H_2O_2 + 2KMnO_4 + 3H_2SO_4 = K_2SO_4 + 2MnSO_4 + 8H_2O + 5O_2$, the value of either the peroxid or the permanganate can be determined by using an excess of one or the other in the operation. Then every c.c. of evolved O (reduced to standard temperature and pressure) = 2.824 mg. $KMnO_4$ or 1.519 mg. H_2O_2, as the case may be.

PHARMACEUTIC ASSAYS.

The pharmaceutic assay of organic drugs is accomplished with the aid of extraction apparatus (Soxhlet tube for hot extraction) and various solvents, especially ether, alcohol, and chloroform, or with Prollius's fluid (1 c.c. of stronger NH_4OH, 2.5 c.c. of alcohol, and 32.5 c.c. of ether). The active principle can be extracted by macerating 10 gm. of the finely powdered substance in 100 c.c. of the solvent for twenty-four hours, at the end of which time half the clear liquid is decanted and evaporated until the ether is removed. The residual liquid is treated with 0.5 c.c. of dilute H_2SO_4 and 10 c.c. of H_2O, and filtered into a separating funnel, washing with about 5 c.c. more of water. The resinous and coloring matters in the separator mixture are removed by shaking with two or three portions of ether (10 c.c. each time), after which the remaining aqueous solution is rendered alkaline with NaHO and shaken in the funnel with 1 volume of chloroform and 3 volumes of ether, repeated twice. The three ethereal solutions are evaporated to dryness in a tared beaker, then weighed, and dissolved in very dilute acid and tested volumetrically. When very little alkaloid is present in a crude drug, alcohol (0.820) is an efficient solvent. It may be recovered by distillation and the residue poured into acidulated water.

Glucosids are often removed from the acid solution before rendering alkaline for the isolation of the alkaloids, by shaking with chloroform, benzene, or petroleum ether, and decanting, or separating in a funnel. The detailed processes for assaying opium, cinchona, nux vomica, etc., will be found in the United States Pharmacopeia.

PROXIMATE ORGANIC ANALYSIS.

Extract fats with ether, extractives with hot alcohol, and soluble minerals with hot water, leaving proteins and insoluble minerals. Volatile oils are separated from resins by shaking with gasolin.

ULTIMATE ANALYSIS.

Ultimate or elementary analysis is accomplished by means of a combustion tube and furnace connected by means of tubing, first, with a U-shaped tube containing dry $CaCl_2$, and, second, with a bulbed tube (Geissler's) containing a strong solution of KHO. A gram or less of the substance is mixed with about ten times as much CuO, placed in the combustion tube, and heated for a sufficient period. The CuO helps to burn any organic matter.

H is converted into H_2O, which is absorbed by the $CaCl_2$ and estimated as one-ninth the increase in weight of this tube. C is changed to CO_2, which is taken up by the KHO, increasing its weight thereby; three-elevenths of this increase represent the C evolved.

N is usually determined by heating the substance with soda-lime (quicklime and caustic soda) and passing the NH_3 gas evolved into a beaker containing a given quantity of normal HCl solution. The diminution in acidity is measured with normal alkali solution, and from this factor the weight of NH_3 and of N obtained by comparison of molecular and atomic weights. Or the NH_3 may be passed into HCl, which is then evaporated over the water-bath, leaving a residue of NH_4Cl.

S and P are estimated by fusing the substance with KNO_3 and Na_2CO_3 in a crucible. C and H are driven off as CO_2 and H_2O, and S and P are oxidized into H_2SO_4 and H_3PO_4, respectively. The fused mass is dissolved in water; H_2SO_4 is pptd. by $BaCl_2$ as $BaSO_4$; and H_3PO_4 by NH_4Cl, NH_4OH and $MgSO_4$ as $Mg_2P_2O_7$.

O is generally determined by deducting the weight of all the other elements from the total weight of the substance taken to be analyzed. If the organic compound is nitrogenous, or if it contains any halogens, a silver or copper spiral should be placed in the front part of the combustion tube and be kept at a low red heat, in order to prevent oxids of N or the haloid elements from going over into the collection tubes and vitiating accurate results. Organic compounds containing S should be oxidized with $PbCrO_4$ before being put into the combustion tube.

C and H in an organic liquid are determined by weighing in a capillary bulb, placing in a Pt boat in a combustion tube with CuO, and heating gradually. Cl, Br, and I, in inorganic compounds, are determined by heating with pure CaO in a combustion tube. The resulting salt is dissolved in dilute HNO_3, $AgNO_3$ added, the ppt. collected, washed, dried, and weighed.

FINDING THE MOLECULAR WEIGHT.

The molecular weight of a compound is twice its vapor-density, hence the determination of the latter and of the percentage of each element in the compound furnish data from which the empiric formula is reckoned, as heretofore described. The Victor Meyer vapor-density apparatus consists of (1) a large glass tube with a bulb at the bottom containing water or some other fluid whose b.p. is constant. The stopper of this tube is perforated and fitted with another smaller tube (2) with a cork at its upper end, in which is held by a wire support the little glass vial holding the liquid substance to be tested, and which has been carefully weighed. This inner tube is provided with a side delivery tube (3) to allow the escape of heated air, the open end of this branch tube being kept in a cup (4) under water, until the bubbles of air driven out by the boiling liquid in the bulb cease to appear. At this point the vial is let fall, and as the liquid boils in the bulb the resulting vapor from the added substance drives out through the delivery tube an equal volume of air, which is collected in the graduated tube (5), or eudiometer, previously filled with water and placed over the open end of the delivery tube. The vapor density is determined from the vapor volume (due allowance being made for the temperature of formation, namely: that of the liquid in the outer tube) by dividing the weight of the substance taken (usually not more than 0.1 gram) by the weight of a volume of H equal to the volume of air collected in the eudiometer. A general formula for calculating vapor density according to this method is as follows:—

$$D = \frac{S \times 760 \times 1.003665t}{V \times (B - w) \times 0.001293}$$

in which *D* stands for density, *S* for weight of substance, *t* for temperature, *V* for volume of air displaced, *B* for barometric reading, and *w* for water-vapor tension at the temperature of the observation. As air is 14.435 times as heavy as *H*, the value of *D* obtained in the above formula must be multiplied by this factor.

Another method of determining the molecular weight of organic substances is by dividing the constant of f.p. depression in solvents (19 for water) by the actual lowering of this point in a given solution of a certain strength, calculated to 1 per cent. of the solvent. The process depends upon the law of Raoult: Solutions containing, in equal volumes of a solvent, quantities of dissolved substances proportional to their molecular weights have the same f.p.

ANALYSIS OF AMALGAM ALLOYS.

The qualitative tests are readily effected by treating the alloy with HNO_3 (1.20), which dissolves out all the metals except Sn and Sb (oxidized) and Au and Pt. Sb and Sn are removed from the residue by hot strong HCl, and then the Au and Pt may be taken up with aqua regia. The acid solutions should be evaporated to dryness at a moderate heat and the nitrates or chlorids taken up with water, filtered, and analyzed in the ordinary way.

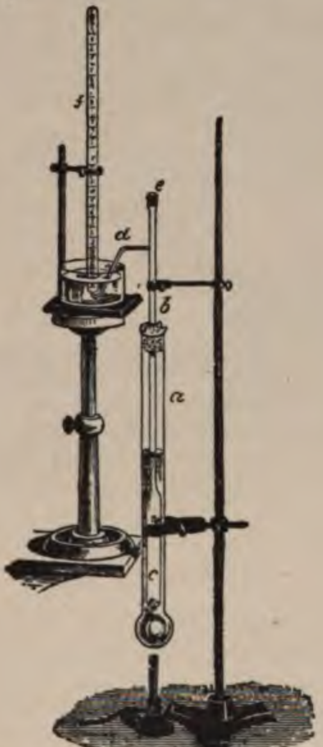

Fig. 55.—Victor Meyer Apparatus.

The quantitative analysis embraces the following steps:—

1. Boil with HNO_3 in a beaker to dissolve Cu (may be green or blue), Ag, Zn, and Cd, but not Au, Pt, Sb, or Sn (whitish ppt. if alone; colored light to deep purple if Au present, dirty black if Pt or Pt and Au). Evaporate to dryness over water-bath, add distilled water, stir well, and filter.

2. Throw down Ag with HCl, reduce to a button of the metal, and weigh. Filter.

3. Add 10 per cent. NH_4OH to ppt. Cu (blue) if present, and filter.

4. H_2S gives a black (Cu) or yellow (Cd) ppt.; a brownish-yellow color means that not all the silver has been pptd.

5. Boil filtrate of No. 4 down nearly to dryness (to expel H_2S), dilute, and neutralize with Na_2CO_3. A white ppt. = Zn.

6. To estimate Sn ignite the residue thoroughly; then cool and weigh. The resulting SnO_2 multiplied by 0.788 gives the actual weight of Sn. If Au is also present, the Sn is calculated by difference after finding the weight of the gold.

7. Au and Pt are dissolved by aqua regia. The Pt may be pptd. by treating the aqueous solution, after evaporating the acid, with NH_4Cl and alcohol; the ppt. is heated and weighed. The gold is then pptd. with $FeSO_4$ or $H_2C_2O_4$, heated to redness and weighed.

8. Hg is easily determined by weighing, heating to redness, and weighing again; the difference represents this metal, the vapors of which discolor ammonio-silver nitrate on filter-paper.

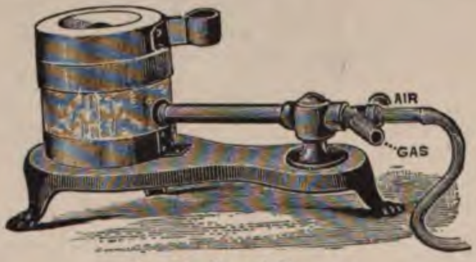

Fig. 56.—Dental Furnace.

REFINING OF GOLD.

Dry Method.—Heat a clean clay crucible (not exceeding 2¼ x 2 inches) to redness in the furnace, place in the gold, add a few crystals of saltpeter, replace the furnace-cover, and melt the gold quickly. Clean and oil an ingot mold, keep it warm while the gold is melting, and pour the metal into it by means of tongs. Then remove the ingot, wash it, and anneal it to a cherry-red; plunge into dilute H_2SO_4, wash, dry, roll, and re-anneal. If the ingot cracks, transfer it again to the crucible and heat as high as possible until molten, add some more crystals of saltpeter, turning the crucible so as to mix well, continue roasting for some time, and pour again into the mold. All the baser metals except Sn and Pb are oxidized by KNO_3, and these are readily chloridized by heating with $HgCl_2$. If Ag is present, add Sb_2S_3 to furnish S to combine with it. An assay ton (A. T.) is 29.166 grams. Its ratio to a ton is the same as that of 1 mg. to 1 ounce troy. Hence, every mg. obtained from one A. T. of ore represents one ounce troy of metal per ton of ore.

Wet Method.—Dissolve in aqua regia—3½ oz. for each ounce of gold—(which ppts. AgCl), let settle, siphon solution carefully into an evaporating dish, heat to evaporate, and repeat siphonage and heating until residue of AgCl ceases to form. Then add gradually to this a clear, filtered solution of $FeSO_4$ (5 parts for 1 of gold). Au is thrown down as a brown powder. Let settle, filter, and wash; digest deposit in dilute HCl (to free from traces of iron), filter again, wash well, and melt powder to a button in furnace. A solution of $AuCl_3$ warmed with an alkaline solution of H_2O_2 is at once reduced to metallic gold. Absolutely pure gold can be obtained only by the wet method, and if Pt is present this method must be employed.

SCHEME FOR DIFFERENTIATION OF FATS (AUSTIN).

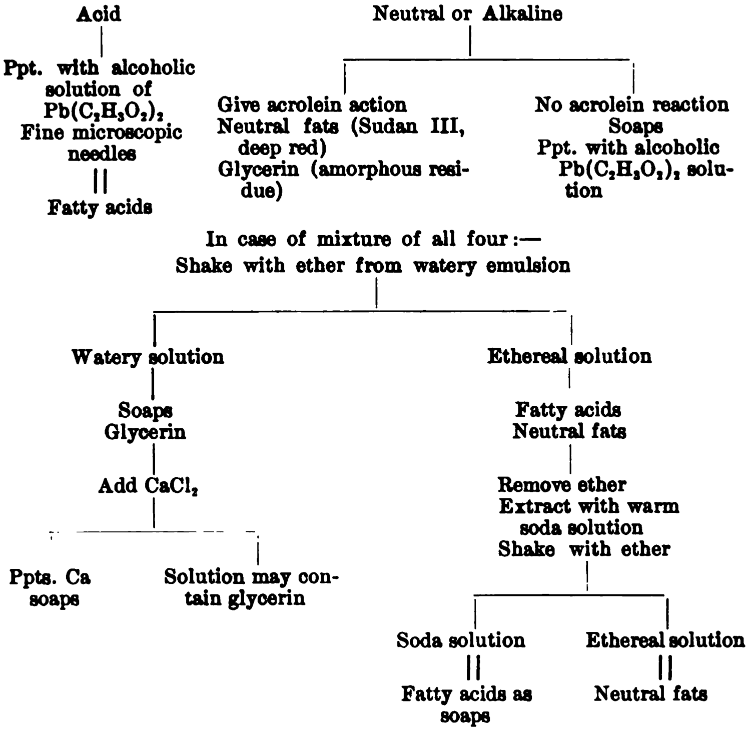

TABLE FOR THE IDENTIFICATION OF THE PRINCIPAL FIXED OILS. (AFTER BARTLEY.)[1]

NAME.	SP. GR. (15° C.).	SOLIDIFYING TEMPERATURE (C.).	RISE IN TEMPERATURE (C.) OF 1 GM. OIL AND 1 GM. BR.	H_2SO_4 COLOR-TESTS: 1 OR 2 DROPS TO 20 DROPS OF OIL.	HNO_3 (1.32) COLOR-TESTS: 1 DROP TO 3-5 DROPS OF OIL.
Almond . . .	0.914 to 0.920	—10 to 20	20 to 21	Yellow or colorless; dark yellow to brown on stirring.	Colorless; becomes solid.
Bees-wax . . .	0.959 to 0.969	62 to 64			
Cacao-butter .	0.995 (0.857 at 98°)	30 to 34			
Castor	0.950 to 0.970	—18	20 to 22	Yellow to pale brown.	Transient yellow or orange.
Cocoa-nut . . .	0.868 to 0.874 at 98°	20 to 28	3.3		
Codliver . . .	0.925 to 0.931	. . . .	34 to 35	Dark-red spot with purple streaks.	Brownish red.
Cotton-seed . .	0.922 to 0.930	1 to 4	24	Bright red, turning dark red to black on stirring.	Red to orange.
Croton	0.942 to 0.955	. . . .	26		
Lard	0.915	4 to 10	18	Greenish yellow to brown; mottled on stirring.	Colorless or transient yellow; elaidin.
Linseed	0.930 to 0.937	—20 to —27	30 to 31	Brown, hard clot; mottled brown on stirring.	Red or orange.
" (boiled) .	0.939 to 0.950	. . . .	30	Brown, hard clot; mottled brown on stirring.	" "
Neat's-foot . .	0.914 to 0.916	Below 0	13 to 16	. . . .	Becomes hard or buttery.
Olive	0.914 to 0.917	+4 to 6	20 to 23	Yellow-green to brown.	Colorless or yellow to green; elaidin reaction.
Sesame, or teel .	0.921 to 0.924	—5 to +5	23	Brown.	Yellow to orange.

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[1] Color tests with oils may be performed by dissolving a drop of the oil in 1 cubic centimeter of chloroform, then adding a drop of H_2SO_4.

QUALITATIVE DETECTION OF THE COMMON SUGARS. (ALLEN.)

METHOD.	DEXTROSE, $C_6H_{12}O_6$.	LEVULOSE, $C_6H_{12}O_6$.	MILK-SUGAR, $C_{12}H_{22}O_{11} + H_2O$.	MALTOSE, $C_{12}H_{22}O_{11} + H_2O$.	CANE-SUGAR, $C_{12}H_{22}O_{11}$.	DEXTRIN, $(C_6H_{10}O_5)x$.
1. Moisten the solid sugar with water, and stir, in the cold, with concentrated H_2SO_4.	Not affected when pure.	Not affected when pure.	Not affected.	Slightly reddish or brownish, gradually turning darker.	Charred.	Not affected.
2. Triturate the solid sugar with NaHO, or boil it with a 3-per-cent. solution of NaHO for one minute.	Deep-brown coloration.	Deep-brown coloration.	Not affected.	Slightly discolored.	Not affected.	Not affected.
3. To the neutral aqueous solution add a few drops of Fehling's copper solution (see "Urine"), and heat to boiling for a few minutes.	Red ppt. of Cu_2O.	Red ppt. of Cu_2O.	Red ppt. of Cu_2O.	Red ppt. of Cu_2O.	Not affected.	Not affected.
4. Heat the solution to boiling for half an hour with $\frac{1}{20}$ its bulk of strong H_2SO_4, neutralize with soda, and heat to boiling with Fehling's solution for a few minutes.	Red ppt. of Cu_2O.	Red ppt. of Cu_2O.	Red ppt. of Cu_2O.	Red ppt. of Cu_2O.	Red ppt. of Cu_2O.	Red ppt. of Cu_2O.
5. To a few drops of Fehling's solution add NaHO and NH_4OH, heat to boiling, and add the saccharin solution drop by drop, keeping the liquid boiling (Pavy's test).	Liquid decolorized.	Liquid decolorized.	Liquid decolorized.	Liquid decolorized.	No change.	No change.
6. Boil the solution for two minutes with 1 c.c. of a liquid containing 4 per cent. of $Cu(C_2H_3O_2)_2$ and 1 per cent. of $HC_2H_3O_2$.	Red ppt. of Cu_2O.	Red ppt. of Cu_2O.	No change.	No change.	No change.	No change.
7. Observe the solution in the polarimeter.	Dextrorotatory (+ 52.5°).	Levorotatory (— 98°).	Dextrorotatory (+ 52.5°).	Dextrorotatory (+ 140.6°).	Dextrorotatory (+ 73.8°).	Dextrorotatory.
8. Heat the solution with diluted acid, as in Test 4, and observe again in the polarimeter.	Dextrorotatory power unchanged.	Levorotatory power unchanged.	Dextrorotatory power increased.	Dextrorotatory power diminished.	Dextrorotatory power changed to levorotatory.	Dextrorotatory power diminished.

COLOR-REACTIONS OF COMMON ALKALOIDS.[2]

NAME.	CONC. H_2SO_4.	H_2SO_4 + HNO_3 (A DROP).	H_2SO_4[1] + SUGAR.	H_2SO_4 + 1 P.M. H_2MoO_4.	HNO_3 (1.40).	CONC. HCl.	H_2SO_4 + $K_2Cr_2O_7$.	NEUTRAL Fe_2Cl_6.	OTHER REACTIONS AND TESTS.
Aconitin . . .	Grad. violet	Grad. violet	Beautiful red	Yellow-brown	Red-brown	. . .	. . .	Yellow ppt.	Dilute solution touched to tongue causes numbness and tingling.
Apomorphin .	Violet to light brown	Dark purple	. . .	. . .	Purple-red	. . .	. . .	Green	Na_2CO_3 ppts. white alkaloid; soon turns green and colors chloroform blue or violet.
Atropin	. . .	. . .	Sulphate violet to brown	. . .	. . .	Aromatic odor	Green solution	. . .	Weak solution dilates pupil; $AuCl_3$ gives a yellow ppt.
Berberin . . .	Olive-green	Olive-green	. . .	Brown-green	Brown-red	. . .	Black resin	. . .	Red color on dissolving in HCl and a little Cl water added.
Brucin	. . .	Red	. . .	Red	Intense red	. . .	Orange	. . .	Fresh Cl water colors brucin solution red, then violet; decolorized by excess.
Caffein	. . .	. .	. . .	. . .	Yellow	. . .	. . .	Slowly green	$KClO_3$ + HCl oxidize caffein or thein; products turn purple-red with NH_4OH.
Cinchonidin .	. . .	. . .	. . .	. . .	.	. . .	. . .	. . .	Negative to quinin tests; salt solutions levorotatory; herapathit test.
Cinchonin . .	. . .	. . .	. . .	. .	. . .	. . .	. .	. . .	Negative to quinin tests; salt solutions dextrorotatory; phenol renders turbid.
Cocain	Chars with hot acid	. . .	. . .	. . .	On evap. KOH gives peppermint odor	. . .	Red, slowly green	Reduced yellow-red	Local anesthetic and mydriatic. Yellow ppt. with K_2CrO_4, $PtCl_4$, or picric acid.
Codein	Dilute pink	Grad. blue	Red	Green, then blue	Red-yellow solution	. . .	Olive-green	$Fe_2(OH)_6$ ppt. on warm.	Solution in H_2SO_4 on warming with trace of Fe_2Cl_6 turns deep blue.
Colchicin . . .	Yellow	Blue	Yellow	Yellow	Blue	. . .	Green to brown	Greenish brown	$AuCl_3$ gives a ppt. that turns red quickly.
Coniin	Purplish to olive	. .	. . .	. . .	Blood-red	. . .	. . .	Ppt.	$AuCl_3$ gives a light-yellow ppt.; $CuSO_4$ gives a blue ppt.
Gelsemin . . .	. . .	.	Red to blue	Gelseminin, violet	. .	. . .	. . .	. . .	H_2SO_4 + MnO_2 color crimson, changing to green.
Homatropin .	Flower odor	. .	. . .	. . .	. . .	. .	. . .	. . .	HNO_3 solution residue is colored yellow by alcoholic solution KHO; dilates pupil.

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[1] The substance to be tested is mixed with 6 parts of cane-sugar, and a minute quantity of the mixture is added to a drop of pure H_2SO_4 on a white plate.

[2] The reactions are usually evanescent.

COLOR-REACTIONS OF COMMON ALKALOIDS (*Concluded*).

NAME.	CONC. H_2SO_4.	H_2SO_4 + HNO_3 (A DROP).	H_2SO_4[1] + SUGAR.	H_2SO_4 + 1 P.M. H_2MoO_4.	HNO_3 (1.40).	CONC. HCL.	H_2SO_4 + $K_2Cr_2O_7$.	NEUTRAL Fe_2Cl_6.	OTHER REACTIONS AND TESTS.
Hydrastin . .	Yellow-red, purple hot	. . .	. . .	Dark green	Yellow to orange	. . .	Bright red	. . .	Dilute salt solutions are fluorescent; tungstates give brownish-lilac tinge.
Hyoscin . . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	HNO_3 residue turns violet on adding alcoholic solution KHO. Dilates pupils.
Hyoscyamin .	. . .	. . .	. . .	. . .	. . .	. . .	Dirty color	. . .	$AuCl_3$ gives a yellow crystalline ppt., soluble in boiling H_2O acidulated with HCl.
Morphin . . .	May be faint pink	Violet	Rose to violet	Violet	Orange to yellow	. . .	Brown	Blue to green	Yellow ppts. with $AuCl_3$, $PtCl_4$, chromates, or picric acid; reduces $AgNO_3$, etc.
Narcotin . . .	Grad. yellow	Reddish violet	Faintly red	. . .	Yellow to red	. . .	. . .	. . .	Fine red residue from evaporated dilute H_2SO_4 solution.
Nicotin	. . .	. . .	. . .	. .	Orange	Violet	. . .	Ppt. solution	Characteristic odor. $AuCl_3$ or $PtCl_4$ gives light-yellow ppt.
Physostigmin .	Yellow to red	Grad. red	. . .	. . .	Yellow to red	Reddish	. . .	. . .	$CaCl_2$ colors red; turns green on heating. A trace contracts pupil.
Pilocarpin . .	Yellowish	. . .	. . .	. . .	. . .	. . .	Emerald green	. . .	Myotic and sudorific; triturated with calomel, turns black when breathed on.
Piperin . . .	Dark red	Grad. green	. . .	Yellow to brown	Orange to red	. . .	. . .	Ppt. HCl sol.	Sharp, biting sensation on holding on tongue; $HC_2H_3O_2$ sol. + $NaNO_2$ = red.
Quinin	Slightly yellow	. . .	. . .	Greenish	. . .	. . .	Light yellow	. . .	Solution (fluorescent) shaken with Cl or Br water turns bright green on adding NH_4OH.
Strychnin . . .	Yellow, warm	. . .	. . .	. . .	Dilute yellow	Yellow, warm	Blue, violet, red, yellow	Brown-green ppt.	Ceroso-ceric oxid added to a trace dissolved in a drop of H_2SO_4 shows blue, violet, red.
Veratrin . . .	Yellow, red, violet	Grad. red	Grad. blue	Grad. red	Yellow solution	Blood-red on heating	Red-brown	Ppt. sol. in HCl	Br water colors violet.

[1] The substance to be tested is mixed with 6 parts of cane-sugar, and a minute quantity of the mixture is added to a drop of pure H_2SO_4 on a white plate.

QUESTIONS ON ANALYTIC CHEMISTRY.

1. Which is the more delicate test reagent for Pb, HCl or H_2S?

2. What is the black ppt. formed when NH_4OH is added to a mercurous solution?

3. What is the gray ppt. obtained by boiling $HgCl_2$ with a stannous solution?

4. Why cannot H_2S be employed in a solution containing free HNO_3? How separate the silver from the copper in a dime?

5. What is the object of NH_4Cl in the third group reagents?

6. How can one obtain Cu from a solution in KCN?

7. What is the formula of the ppt. obtained by adding KCl to a Pt solution?

8. Why does Ag_2CO_3 turn black on heating?

9. Explain reddish-brown change of color on treating Prussian blue with alkalies. How do acids restore the blue color?

10. Why is charcoal used for reduction tests?

11. What weight of $Ca(HO)_2$ in 10 c.c. of a decinormal solution of this compound?

12. Calculate the neutralizing equivalent of potassium acetate.

13. What is the brownish ppt. obtained by heating cocain with dilute H_2SO_4, neutralizing with KHO and adding $FeCl_3$?

14. Mention five analytic distinctions between As and Sb.

15. How much $CuSO_4$ does 48 gm. of pptd. CuO represent?

16. In preparing a normal acid solution, if 10 c.c. of normal alkali neutralize 6.8 c.c. of the dilute acid, what percentage of water must be added to the latter to complete the preparation?

17. How many c.c. approximately of concentrated H_2SO_4 and HCl are required to make a normal solution of each?

18. How much $KC_2H_3O_2$ (burned to K_2CO_3) is present in a solution which requires 15 c.c. of decinormal HCl solution to decolorize the phenolphthalein?

19. Calculate the decinormal equivalence in oxidimetry of sodium nitrite.

20. How much O does $K_2Cr_2O_7$ give off in oxidizing other substances in presence of H_2SO_4? Calculate the number of grams per liter of the dichromate in a normal solution.

21. One gram of a proteid substance yields as much N as will diminish the acidity of normal HCl from 12 to 8 c.c. of normal alkali. Find percentage of N in the compound.

22. Show by equation of formulas and molecular weights why one-half the gram-molecular weight of H_2SO_4 should be taken in making a normal solution of this acid.

23. What part of the flame is best for cleaning the Pt wire?

24. How can one prepare black, reddish, gray, green, yellow, and white specimens containing As for medico-legal purposes?

25. Explain the darkening on boiling of a Cu solution to which KHO has been added.

26. Explain object of each step in Liebig's test for HCN.

27. A slip of filter-paper, moistened with a drop each of K_3FeCy_6 and $FeCl_3$, shows a blue spot on adding a drop of a cocain solution. Explain.

28. Explain changes in rotatory power on polarized light, produced by heating various sugars in solution with dilute acids.

29. One-tenth gm. alcohol yields with the Victor Meyer density apparatus 48.5 c.c. of air in the eudiometer, after making corrections for temperature and pressure. Calculate the molecular weight of the alcohol.

30. A 10 per cent. aqueous solution of dextrose freezes at about —1.06°, and ultimate analysis of dextrose shows 2 parts of H to 1 each of C and O. Calculate from these data the formula of dextrose.

31. Write equation for reaction between solution of As_2O_3 and ammonio-copper sulphate, forming green ppt. of $CuHAsO_3$.

32. Give reasons for steps in the U. S. P. method of assay for morphin in opium. These steps consist essentially in extraction with water, and the addition in order of alcohol, ether and ammonia-water.

33. How can Hg be tested for in the original solution in the presence of other substances?

34. How could you separate sulphates in solution from halogen salts or phosphates, borates or arsenates?

35. How could you remove a stain of Cu or Ag from a test-tube? One of grease or animal matter?

36. What may cause the Bunsen burner to "strike back"?

37. How determine the presence of borax accompanying sulphites?

38. A certain white sublimate on heating with Na_2CO_3 turns red; what is it? Explain color change.

39. How may the illuminating gas in the Bunsen give rise to error in the hepar test?

40. In a second group solution, H_2S gives a yellow ppt.; what elements are absent?

41. Give two ways of distinguishing mercurous and mercuric salts.

42. When pptg. $AgNO_3$ with arsenic acid, why is it necessary to add a base?

43. When the ppt. of acid sulphids obtained with HCl is colored brown, what element is probably present?

44. If in the second group pptn. with H_2S a red ppt. is formed, which finally turns black, what element would you expect to find?

45. When KOH is added in excess to a solution of the second group metals, what metals are pptd.?

46. A white ppt. in a second group mixture may be what? A gray ppt.? A green ppt.?

47. Why must the second group ppt. be acid before pptg. with H_2S?

48. Why is the yellow, not the colorless, ammonium sulphid used in the separation of the acid sulphids?

49. Give two ways to distinguish ferric from ferrous salts.

50. A solution containing one element gives a red flame test. How can you determine in one operation whether it is Sr or Li?

51. Why is it that Sr is tested for by $CaSO_4$ and not by H_2SO_4?

52. If to a solution containing ferrous and ferric iron KCN is added, what is the result?

53. A solution known to contain but one metal gives a black ppt. with $(NH_4)_2S$, soluble in dilute HCl. What is the metal?

54. The salts of which acids give off gases when diluted with dilute H_2SO_4?

55. A solution to be tested for acids gives a white ppt. with $BaCl_2$ and with $Pb(C_2H_3O_2)_2$, a yellow ppt. with $AgNO_3$; both ppts. being soluble in acids. What acids would you expect to be present?

56. How test for potassium ferrocyanid in the presence of potassium ferricyanid?

57. A solution treated with H_2SO_4 gives off a gas which colors KI starch paper blue? What acids may be present?

58. If a solution on treatment with strong HNO_3 turns milky, what acid ions may be present?

59. What acid ion is indicated when a solution yields a dirty green ppt. with $(NH_4)_2S$?

INCOMPATIBILITY.

GENERAL RULES OF INCOMPATIBILITY.

Two or more substances may be unsuitable for combination, because of physic disassociation or immiscibility, chemic decomposition, or therapeutic antagonism. Only physic, or pharmaceutic, and chemic incompatibilities will be considered here. Chemic changes in solution without precipitation or gas-formation are not usually classed under incompatibility.

The solvent power of water, alcohol, or ether for particular substances diminishes in proportion to the amount of the other added. Thus, camphor is insoluble in water, and if water is added to spirit of camphor the stearopten is pptd. more or less according to the amount of water added. The quantity of alcohol is not decreased, but its solvent power for the camphor is diminished by adding another liquid in which the camphor is insoluble.

In accordance with this general rule, alcoholic (resinous) tinctures and fluid extracts are incompatible with aqueous preparations; and tinctures made with alcohol with those made with dilute alcohol (gum resins). Infusions generally are incompatible with metallic salts, and immiscible with alcoholic tinctures and preparations containing resinous or oily matters. Very soluble salts throw volatile oils out of solution from aromatic waters; water and saline solutions separate them from alcoholic solutions. Glycerin is not a solvent for oils. The scale salts of iron when powdered form a sticky mass but slowly soluble in hot water.

When mixing resinous tinctures or fluid extracts with water, add to the cold water slowly in a fine stream. Use one-half or twice as much water with alcoholic solutions, according as precipitation of the substance depends on its insolubility in water or alcohol, and change dose accordingly. In cases where solution cannot be secured or maintained, emulsify with acacia (make a dilute mucilage and add alcoholic fluid gradually), tragacanth (add tincture or fluid extract directly to powdered drug, shake and add 20 times as much water as gum, and shake vigorously), syrup (for light bodies), or glycerin (fluid extracts).

The two laws of Berthollet comprise the essential facts of all chemic incompatibility. The first law is as follows: When two or more substances are brought together in solution, if by any rearrangement of atoms a new substance can be formed which is insoluble in the liquid present, it will quickly form and be precipitated. The second law is like unto the first, except that volatile compounds are formed in place of precipitates; as when any carbonate is treated with an acid, CO_2 is evolved.

Other general rules of chemic incompatibility are the following: Substances are incompatible with their tests and antidotes. Acids neutralize bases and basic oxids, forming salts and water. Two or more acids or two or more bases acting on each other form salts of all the components, the amount of each salt depending on the quantity of each ingredient and their relative affinity. Stronger acids displace weaker ones in mineral or alkaloidal salts; stronger hydrates and carbonates displace weaker bases and alkaloids. Organic substances are insoluble in the fluids by which they are pptd. from solution.

It will be noticed that a thorough knowledge of incompatibilities must be based upon the solubilities of drugs, especially in water, and the appended table should be of service for reference in this connection. (See next page.)

SUMMARY OF SOLUBILITIES OF MEDICINAL SALTS.

Soluble in Water. — Practically all medicinal acetates, benzoates, bicarbonates, bromates, bromids, chlorids (except calomel), citrates, cyanids, hypochlorites, iodates, lactates, nitrates, nitrites, sulphites, tartrates, thiosulphates, solid acids, gums, mucilages, starches, sugars, and albuminous bodies.

Soluble in Dilute Acids (Insoluble in Water).—In general, the phosphates, carbonates, arsenates, arsenites, and sulphids of all except alkali metals; oxids and hydroxids of all except the alkalies and alkaline earths and arsenic; iodid of arsenic, antimony, copper, bismuth, mercury, silver, lead; oxysalts of bismuth and antimony; and sulphates of lead and of the alkaline earths ($BaSO_4$ quite insoluble). Acids often cause no incompatible reaction, while the corresponding salt does.

Soluble in Alcohol.—Most organic bodies except carbohydrates, namely: alkaloids, glucosids, volatile oils, castor-oil, resins, camphors, balsams; HgI_2, $HgCl_2$; benzoic, salicylic, and valeric acids; most medicinal acetates, benzoates, nitrates, salicylates, valerianates, I, and halogen salts; nearly all other salts are insoluble in alcohol except those which are deliquescent (efflorescing salts insoluble). Dilute alcohol is the solvent for gum resins.

Glycerin is an excellent solvent for alum, borax; boric, gallic, tannic, and carbolic acids; starch, iodin, creosote, and many metallic salts (PbO, $BiONO_3$, etc.), especially deliquescent ones.

Fixed oils dissolve iodoform, carbolic acid, stearoptens, P, S; turpentine dissolves fats, fixed oils, S, and paints; ether dissolves fats, fixed oils, and oleoresins; chloroform dissolves gutta-percha.

TABLE OF SOLUBILITY OF SALTS, ACIDS, AND BASES.

Blank spaces = soluble in water; S = sparingly soluble in water; A = soluble in dilute acids; Sa = sparingly soluble in acids; X = insoluble in water or acids; dots = unknown.

	ACETATE.	ARSENATE.	ARSENITE.	BENZOATE.	BORATE.	BROMID.	CARBONATE.	CHLORATE.	CHLORID.	CHROMATE.	CITRATE.	CYANID.	FERRICYANID.	FERROCYANID.	FLUORID.	HYDROXID.	HYPOCHLORITE.	HYPOPHOSPHITE.	IODID.	LACTATE.	NITRATE.	NITRITE.	OXALATE.	OXID.	PHOSPHATE.	SALICYLATE.	SILICATE.	SULPHATE.	SULPHID.	SULPHITE.	TARTRATE.	VALERIANATE.
Aluminum		A		......	A		A			....		......	....	....		A	....			....		..	A	A	A	....	Sa		A	....		....
Ammonium																	....			....		..		....			....					
Antimony		A	A	......	....	Sa	....	.	Sa	A	....	......	....	....		A	....		Sa	....	..	..	A	A	Sa	....	....	A	A	....		....
Arsenic			....	......	....		....	..		....	....	......	....	....	....	....	....			....		..	....	Sa	....	....	....	....	A	....	......	....
Barium		A	A		A		A			A	A	Sa	....	Sa	Sa	Sa				....			A	Sa	Sa	....	A	X		A	A	....
Bismuth		A	A	......	A	Sa	A		Sa	A		......	....	....		A			A	....			A	A	A	A	....	Sa	A	....	A	X
Cadmium		A	A		Sa		A			A	A	A	....	....	Sa	A				....			A	A	A	....	A		A		Sa	....
Calcium		A	A		A		A			Sa	Sa				A	Sa	Sa					..	A	Sa	Sa	....	A		Sa	Sa	A	....
Chromium		A	A	......	A	Sa	A			....		A		....		A				....		..	Sa	Sa	A	....	A	Sa	Sa			....
Cobalt		A	A	......	A		A			A		Sa	X	X	Sa	A				....			A	A	A	....	A		A			....
Copper		A	A		A		A			Sa		A		X	A	A		..	A	....			A	A	A	....	A		A	A		....
Ferric		A	A	A	A		A					......		X		A	....	S		....			A	A	A	A	A		A	....		alc.
Ferrous		A	A		A		A			A		Sa	X	X	Sa	A	....	..				..		A	A	....	A		A	A	Sa	....
Gold			....	.....	....					....		KCN	....	....	....	....	....			....	..	..	....	....	....	....	A	....	A	....	......	....
Hydrogen			Sa	alco.												....										alc.						alc.
Lead		A	A	......	A	Sa	A		Sa	Sa		A	A	A	A	A			Sa	....			A	A	A	....	A	Sa	A	A	A	....
Lithium			....				S					.....					....					..	A		Sa		A		A			
Magnesium		A	A		Sa		A								Sa	A	....			....		..	A	A	A	....	A		A		Sa	....
Manganese		A	A		A		A				A	A	X	A	A	A				A			Sa	A	A	....	A		A		Sa	....
Mercuric		A	A	A	....		A			S	A		....	....	....	....			KI	....			A	A	A	....	....		A	....	A	....
Mercurous	Sa	A	A	A		A	A		Sa	A	A	......	....	....	Sa	....			Sa	....			A	A	A	....	....	Sa	A	....	Sa	....
Nickel		A	A	......	A		A			A	A	Sa	X	X	Sa	A				....			A	A	A	....	Sa		A		A	....
Platinum			....	.. ...	....	....	....	..		....	....		....	....	....	....	....	..	....	....	..	..	....	....	....	....	....		A	....	......	....
Potassium																													A		bl. S	....
Silver		A	A	A	A	X	A		X	A	A	X	X	X		....		..	X	....			A	A	A	....	....	A		....	A	....
Sodium																																
Strontium		A	A	......	A		A			Sa	A		....		Sa		....	..					A	Sa	Sa		A	X		....	A	
Tin			....	.....	A		....			A	....		....	....	....		A	..		....			A	A	A	....	A		A	....		....
Zinc			. ..	......	A		A				A	A	A	Sa	Sa	A		..		Sa			A	A	A	....	A		A		A	S

Primary emulsions are made with 1 part of acacia, 4 parts of fixed oil (2 parts of volatile), and 1 ½ or 2 parts of water or lime-water. Tinctura quillaiæ is particularly useful in emulsions containing free acids; alkalies for copaiba.

COMPOUND SOLVENTS IN AQUEOUS SOLUTION.

(Solvents for bodies slightly soluble in water.)

Acetates	Benzoic and carbolic acids, succinates, PbI, PbO, and ammoniated mercury.
Acids	Arsenous and boric acids, quinin sulphate, pepsin (HCl), phosphates, sulphates and carbonates of earthy and alkaline earthy metals.
Alcohol	Overcomes incompatibilities of alkaloids.
Alkalies	H_3AsO_3, ferricyanids and ferrocyanids. $KHC_4H_4O_6$, saccharin and chrysarobin.
Ammonium carbonate	$Bi_2O(OH)_2CO_3$, calcium salts, NH_2HgCl, ZnO.
Ammonium chlorid	Magnesium compounds, $Ce_2(C_2O_4)_3$, PbI_2, $HgCl_2$ (prevents formation of albuminate), and ammoniated mercury.
Ammonium hydrate	$BiC_6H_5O_7$ and $ZnCO_3$.
Borax	H_3BO_3, $HC_7H_5O_3$, $KHC_4H_4O_6$.
Carbonic acid	Carbonates generally.
Glycerin	Carbolic and arsenous acids, alkaloids with borax; keeps fluid extracts from pptg. thymol in water.
Hydrogen peroxid	Tragacanth.
Oxalic acid	Iron salts.
Potass. cyanid	Silver, gold, and copper salts.
Potass. iodid	Iodin, HgI_2, AgI.
Sodium citrate	Gallic acid, $BaSO_4$, phosphates, pyrophosphates, hypophosphites, tartrates, succinates; ferrous salts; Bi, Pb, Cu, Zn, Mn, Ni, Co, Cr, Al salts.
Sodium phosphate	Benzoic acid and other phosphates.
Sodium sulphate	Benzoic acid and sulphate of mercury.
Sugar or syrup	Borax, boric acid, $Ca(HO)_2$, $Fe(HO)_3$, and Fe_2O_3.
Tartaric acid	Tartrates, quinin sulphate.

Precipitation is sometimes prevented by dissolving incompatible salts separately, and then mixing, or by the use of compound solvents.

Tannates are present in vegetable bitters and astringents generally, except quassia, columbo, chiretta, and gentian (darkens with Fe because of contained gentesic acid).

Alkaloidal precipitates are prevented by the use of 15 to 40 per cent. of alcohol in solution.

Hydrate or carbonate of iron is held in solution or suspension by citrates, tartrates, sugar or glycerin.

Preparations containing acids: Official vinegars; citrate of iron and quinin; extract of colchicum; fluid extracts of conium, ergot, nux vomica, and sanguinaria; infusions of cinchona and rose; mixture and solution of ammonium acetate; solution of acetate of iron, arsenous acid and ferric chlorid and nitrate;

PRACTICAL PHYSIC AND CHEMIC INCOMPATIBILITY AS APPLIED TO MEDICINE.

ACIDS, BASES, AND SALTS.	AG, PB.	CA, SR.	K, NA, LI, NH_4.	AL, MG.	FE.	HG.	ZN, CU.	AS.	ALKALOIDAL SOLUTIONS.	MINERAL ACIDS.	ALBUMIN, GELATIN.	ALCOHOL.	GLYCERIN.	SOLVENT OF PPTS.
Acetic and acetates	....	..	....	..	..	..	..	..	P (quin.)	....	....	P (Ag)		
Arsenites and arsenates	P	P	....	P	P	P	P	..	P	....	....	P	....	HCl.
Benzoic and benzoates	....	.	....	..	P		..	..	....	P	....	....	....	Acetates and phosphates.
Boric and borates	P	P	....	P	P	P	P	P	P	....	....	P	frees acid	Boric or tartaric acid, borax, tartrates.
Hydrobromic and bromids	P	..	....	..	..	.	..		strych.	Br				
Carbonic and carbonates	P	P	Li	..	..	alk.	..	..	alkaline	CO_2	....	P	....	Excess of CO_2 or acids.
Hydrochloric and chlorids	P		..	..	..	..	..	..	berberin	....	....	Na, K, Li, Pb, Ag		
Chlorates	....	..	....	..	..	..	..	..	....	Cl				
Chromates	P	P	P	P	P	P	P	P	P	....	....	P	....	HNO_3
Citric and citrates	P	P	....	..	P	P	P	P	....	....	....	P	...	NH_4HO.
Hydrocyanic and cyanids	P	..	....	P	P	..	P	P	P	....	....	P, exc. Hg	....	KCN and acids.
Ferro- and ferri- cyanids	P	..	....	P	P	P	P	P	....	HCN	....	P	....	Acids or alkalies.
Gallotannates	P	..	....	..	P	P	P	P	P (tan.)	....	tannic	tannic	....	Excess.
Hydrates	Ag	..	NH_3	P	P	P	Zn	P	salts	....	....	....	....	Excess of hydrate.
Hypochlorites	....	..	....	..	..	..	..	..	....	Cl				
Hypophosphites	....	..	....	..	P	R	..	..	....	decomp.	....	P, exc. alk.		
Hydriodic and iodids	P	..	....	..	I	P	P	..	P	I	....	Pb, Ag, Hgt	....	KI.
Nitric and nitrates	...	..	...	..	..	..	..	..	....	....	....	K, Pb, Bi		
Nitrites	...	..	....	..	..	..	..	.	....	N_2O_4				
Permanganates	....	..	....	..		.	..	..	....	....	....	oxid	oxid	
Phosphoric and phosphates	P	P	Li	P	P	P	Zn	..	P	....	....	P	....	H_3PO_4, HCl.
Salicylic and salicylates	P	..	....	..	P	..	.	..	quin.	P	....	Hg, Bi	...	HNO_3, alkaline citrates.
Sulphuric and sulphates	P	P	....	..	.	ous	..	..	....	....	....	P		
Tartaric and tartrates	P	P	K (bi)	..	..	P	Zn	..	P	....	....	P	....	Excess.
Valerianates	.	..	....	..	..	.	..	..	....	v. acid				
Acacia	Pb subac.	..	borax	..	P	..	..	..	....	P	....	P	....	Acids or sugar.

syrups of citric and hydriodic acids, calcium lactophosphate, garlic, hypophosphites, ipecac, lemon, and squill; tinctures of ferric chlorid, camphorated opium, and sanguinaria.

Preparations containing alkalies: Elixir of cascara; fluid extracts of licorice and senega (NH_4OH); Fowler's solution; glycerin suppositories; ammonia and lime liniments; rhubarb and soda mixture; compound iron mixture and pill; Seidlitz powder; aromatic spirit of ammonia; ammoniated tinct. valerian; syrups of rhubarb (K_2CO_3), and senega. Fe solutions are incompatible with alkalies.

GAS-FORMATION: EFFERVESCENCE, EXPLOSION, COMBUSTION.

Guard against explosions by using considerable water, mixing slowly, and keeping vessels cool; also by keeping bottles loosely corked. Never rub together in a mortar oxidizing and reducing agents, but powder each ingredient separately, then transfer to a sheet of clean paper and mix with a spatula or by sifting, avoiding pressure. The substances printed in italics are best prescribed alone or in their proper solvents:—

Oxidizing Agents.	Reducing Agents, or Combustibles.
Bromin, bromates.	Ammonium salts and water.
Chlorin, chlorates, hypochlorites.	Arsenous acid.
Chromic acid, chromates, dichromates (in presence of mineral acids).	*Cyanids.*
Ferric, cupric, and mercuric salts.	Ferrous, mercurous, and stannous salts.
Gold and platinum hydrates.	Formaldehyd.
Iodin and iodates.	Hydroquinone, pyrogallol, hydroxylamin hydrochlorate.
Nitrates, nitrites (sometimes), nitric and nitrohydrochloric acids.	Nitrites (sometimes).
Peroxids, permanganates, and persulphates generally.	*Organic substances* (alcohol, charcoal, creosote, ethers, dry extracts, glycerin, oils, oxalates, pyroxylin, sugars, syrups, tannins, powdered vegetable drugs, etc.).
Silver oxid.	*Phosphorus and hypophosphites.*
Sulphuric acid (with organic matter).	*Sulphur, sulphids,* hyposulphites, sulphites.
	Zinc and iron in powder.

Experiment.—Illustrate combustibility and oxidation by mixing in a mortar 15 grains of $KMnO_4$ with a fluidram of H_2SO_4. Dip a glass rod in the solution and touch it to a wisp of cotton, previously saturated with alcohol.

A solution containing $KClO_3$ and HCl is liable to explode at 70° F.:—

$$2KClO_3 + 4HCl = 2KCl + Cl_2O_4 + Cl_2 + 2H_2O$$

Nitric acid is an oxidizer:—

$$2HNO_3 = H_2O + 2NO + 3O$$

It may even set sawdust on fire.

Nitrous ether is incompatible with iodids and acids or acid salts:—

$$C_2H_5NO_2 + KI + KHC_4H_4O_6 =$$
$$C_2H_5OH + K_2C_4H_4O_6 + I + NO$$

A mixture of phenol and nitric acid is explosive.

POISONOUS REACTIONS.

Chlorates with iodids, forming iodate or liberating free caustic I. A little ammonia prevents this pptn. for a time.

Tincture of iron with KI is reduced to ferrous state, and free I is liberated. It is also reduced by bromids, with liberation of Br.

Nitrous ether (acid, decomposed) liberates free I from iodids; this action prevented by neutralizing acid, before mixing, with a little $KHCO_3$.

Chloral hydrate in a mixture of aqueous and alcoholic media forms an alcoholate, which may separate and float on the top, especially in presence of soluble salts.

Dilute HCN or KCN with calomel, forming bicyanid of mercury.

Mercurous salts with bromids, chlorids, iodids, or cyanids form more poisonous double mercuric salts and metallic Hg.

Tincture of digitalis with aqueous or syrupy solutions undergoes spontaneous decomposition, with precipitation of active principles.

SPECIAL INCOMPATIBILITIES.

Strong acids form ethers from alcohol.

Iodin derivatives give up their I with alkalies, oils, silver salts, and organic matter.

Soaps decomposed by acids, alkaline earths, and mineral salts.

Ichthyol incompatible with acids, iodids, fixed alkalies, $HgCl_2$, alkaloids, and strong alcohol.

Formalin is a powerful reducing agent on metallic salts, and is incompatible with ammonia and bisulphites.

Antipyrin incompatible with phenol, alum, HgCl, $HgCl_2$, sodium salicylate, beta-naphtol, syrup of FeI_2, and precipitants of alkaloids.

Salol and aspirin are incompatible with alkalies.

Reducing agents (cocain, hypophosphites, HCN, tartar emetic) change ic salts to ous, and sometimes salts to metals.

H_2O_2 is incompatible with soda, potassa, ammonia, chlorin-water, iodids, ferric chlorid, phenol (oxidized to pyrocatechin and hydroquinon), glycerin (oxidized to glyceric acid, $C_3H_6O_4$), oxalic and tartaric acids and potassium permanganate:—

$$2KMnO_4 + 2H_2O_2 = K_2MnO_4 + MnO_2 + 2H_2O + 2O_2$$

Potassium permanganate is decomposed (to MnO_2) by hydrastis and other fluid extracts, forming a dark gelatinous mass. Solutions of $KMnO_4$ should not be kept in contact with cork or rubber or be filtered through paper, since it forms brown hydrated MnO_2.

Chloral or chloralamid decomposed by alkalies, forming $CHCl_3$ and a formate of the alkali.

Tartar emetic incompatible with tannin and antipyrin.

Carbolic acid coagulates collodion and decomposes $KMnO_4$ and H_2O_2 (with formation of MnO_2 and oxalic acid).

Mercuric salts coagulate albumin (soluble in excess of albumin) and gelatin, and ppt. tannin and alkaloids.

Borax forms a gelatinous mass with acacia—liquefied by adding sugar.

Glucosids decomposed into glucose, etc., by free acids or emulsin.

Pepsin is pptd. by many metallic salts.

Pepsin and pancreatin are coagulated by strong alcohol into a flocculent rubber-like mass. Pepsin is decomposed by alkalies and is destroyed by pancreatin.

Nitrous ether darkens with tannin or tannates, liberates I from iodids, and is broken up by acids and alkalies, liberating gases very freely. It gives a green color with antipyrin (prevented by adding an alkali); a yellow or red with acetanilid; a brownish color with salicylates. It tends to become acid (nitrous) on standing.

Compound ethers are incompatible with alkalies, forming alcohol and salts.

Iodin or Ag_2O forms a very explosive compound with ammonium hydrate or salts; NHI_2 explodes when dry.

Tincture of I is decolorized by tannin or NH_4HO (forms NH_4I).

Gallic acid gives a green or brown coloration with hydrates or carbonates, blue with lime-water, bluish black with $FeCl_3$.

Strong acids decompose ammonio-citrate of bismuth.

Aqua regia (free Cl) liberates I from iodids.

Bismuth subnitrate forms a red compound with I and with salicylic acid, and liberates CO_2 in a fluid mixture with bicarbonates.

Ferric chlorid produces a violet color with carbolic and salicylic acids and their salts, creosote (quickly fades brown), phenol radicals (salol, anilin, resorcin, cresols, guaiacol), and oils of cloves, bay, and pimenta; red color with acetates, sulphocyanids, antipyrin, and acacia; flesh color with benzoic acid and benzoates; green with guaiac, aloin, thallin; blue-black with gallic acid; black with tannic acid, tannates, and gentian.

Uva ursi (contains diosphenol, $C_{10}H_{16}O_2$) gives an olive-green color with $FeCl_3$.

Apomorphin is incompatible with alkalies, iodids, $FeCl_3$, picric and tannic acids and silver salts.

Codein may be prescribed with alkalies, since the pure alkaloid is soluble in water.

All reducing agents ($FeSO_4$) ppt. gold from its solutions as a brick-red powder.

Alkaloidal salts form insoluble santalates with compound tincture of lavender.

Eriodictyon, used in masking the taste of bitter substances, forms insoluble combinations with quinin.

LIQUEFACTION ON TRITURATION.

(Substances generally insoluble in water.)

Antipyrin with chloral, sodium salicylate, resorcin, or euphorin.

Sodium salicylate with acetanilid, exalgin, antipyrin, etc.

Chloral with camphor, menthol, phenol, or thymol.

Camphor with beta-naphtol, butyl chloral, menthol, phenol, thymol, and resorcin.

Butyl chloral with camphor, menthol, phenol, or thymol.

Thymol with chloral, menthol, or phenol.

Exalgin with salicylic acid.

Waxed papers should be used for hygroscopic powders.

CHEMIC DECOMPOSITION ON TRITURATION.

Commercial $KClO_3$ may explode singly under sharp contusion.

Hypophosphites triturated alone may decompose, forming H_3P with explosion.

Iodol rubbed with yellow HgO explodes.

Potassium chlorate may explode when rubbed with S, tannin, or picric acid.

Potassium nitrate is explosive when triturated with S and dry K_2CO_3; $KMnO_4$ with picric acid and tannin; $K_2Cr_2O_7$ with tannic and picric acids.

Oxid of silver should not be rubbed with dry organic substances.

Mercurous salts are generally reduced to metallic Hg and mercuric salts when rubbed with other salts. This poisonous change may be prevented by moistening with a little alcohol, water, or oil before rubbing:—

$$2HgCl + 2KBr = HgBr_2{,}2KCl \text{ (very poisonous) } + Hg$$

Calomel and ammonium carbonate rubbed together turn black, owing to formation of Hg_2O and NH_2Hg_2Cl.

INCOMPATIBILITIES OF WATER.

Bismuth nitrate forms insoluble basic nitrate.

Water ppts. $SbCl_3$ as $SbOCl$. It decomposes sulphids of metals, setting free H_2S.

Subacetate of lead carbonates and forms a cloudy mixture with water which has stood in contact with the air.

Mercuric salts and $HgNO_3$ are decomposed (except $HgCl_2$), requiring KI or free acids to effect solution.

Tincture of iodin liberates the element I on diluting with water or aqueous solutions.

Sodium peroxid breaks up with water into NaHO and O_2.

Bismuth chlorid (made by dissolving Bi salts in hot aqua regia) poured into excess of water gives a copious white ppt. of oxychlorid.

INTENTIONAL INCOMPATIBILITY.

This is illustrated by black and yellow wash and by silver nitrate and acetate of lead with opium.

Sodium bicarbonate is frequently prescribed with salicylic acid in order to get fresh sodium salicylate. To make Cl water, HCl is sometimes added directly to $KClO_3$.

PRESCRIPTIONS.

Prescribe salts and acids with the same radical whenever practicable—as tinct. ferri chloridi, liq. arsen. chloridi, acidi hydrochlorici, and hydrarg. chloridi corros.

The following named substances are best given alone in simple solution: Chlorin-water, citrate of iron and quinin, dilute hydrocyanic or nitrohydrochloric acid, iodin, and iodids; liquors calcis, ferri nitratis, potassæ, and potassii arsenitis; morphin acetate or hydrochlorate; potassium acetate, bromid, or permanganate; quinin sulphate; syrup of iodid of iron; tannic and gallic acids; tartar emetic; tinct. ferri chloridi and guaiaci; zinc acetate.

The following combinations have been known to explode: Potassium chlorate and hypophosphites in water; potassium chlorate, tannin, and glycerin; $KMnO_4$, tincture of iron, and glycerin; HNO_3, HCl, and tinct. nucis vomicæ; borax, $NaHCO_3$, glycerin, and H_2O (evolution of CO_2); $KMnO_4$, alcohol, and water; oil of amber and HNO_3; turpentine and H_2SO_4; I and spirit of camphor; CrO_3 and glycerin. Mixtures of NH_4Cl and $KClO_3$ have exploded violently after standing awhile.

Kaolin, talcum, fuller's earth, petroleum, and paraffin are the best excipients for pills and triturates of silver salts (coated with Tolu), potassium permanganate and dichromate. Wheat flour is a good excipient for volatile oils—along with syrup. When it is desired to limit the action of pills or tablets to the intestinal canal, they should be coated with keratin (made from goose-quill) or salol or glutoid (gelatin capsules hardened in formalin). Double gelatin capsules answer about the same purpose. Rice starch is often added to tablets to cause them to break up more quickly when placed in water.

When making suppositories in hot weather, it is advantageous to add a little fixed oil, and in winter 5 per cent. of petrolatum, to the cacao butter. Cerates are prepared by liquefying the greasy base, adding the medicinal agent, and stirring the mixture (to prevent layering) until it cools. Paraffin is an excellent base for stiffening certain ointments and cerates. The addition of 10 per cent. glycerin to solid extracts is recommended to preserve a pilular consistency. A few drops of alcohol or ether render camphor easily pulverized.

Various inert substances are used to give an attractive coloring to pharmaceutic preparations: Carmine or cochineal for red, and glycyrrhizin for brown, are suitable for alkaline and neutral solutions; while cudbear (tinct. persionis) for red, and caramel for brown, are available for mixtures with an acid reaction. Comp. tinct. cardamom contains cochineal. Comp. tinct. cudbear contains caramel as well as cudbear, and so gives a brownish-red hue. A pleasing yellow tint is imparted to either acid or alkaline solutions on adding 1 per cent. or less of tinct. hydrastis.

To improve the taste of medicinal liquids, Sollmann recommends syrup of Tolu or aromatic elixir; for salts, peppermint water or citric acid (2 grains per ounce); for emulsions, comp. spt. orange (6 drops per ounce); syrup of licorice for cough medicines, and elixir of gentian to give a pleasant bitter taste.

ACTION OF AIR, LIGHT, AND ATMOSPHERIC HEAT.

HYGROSCOPIC AND DELIQUESCENT. (Not to be prescribed in cachets.)	EFFLORESCENT COMPOUNDS.
Acids: *Carbolic*, chromic, citric.	Citric (sometimes).
Aluminum: *Chlorid*, *bromid*, *iodid*, acetate.	Phosphate, valerate.
Ammonium: *Chlorid*, *bromid*, *iodid*, nitrate.	
Amylene: Hydrate.	
Antimony: Chlorid.	Tartrate (SbOK).
Barium:	Acetate.
Calcium: *Chlorid*, *bromid*, *iodid*, *oxid*, hypochlorite.	Acetate.
Chloral: Hydrate and butyl.	
Cinchonidin:	Sulphate.
Cobalt: Acetate, chlorid, nitrate.	Sulphate.
Copper: Chlorid, nitrate.	Acetate, sulphate.
Gold: *Chlorid*.	

HYGROSCOPIC AND DELIQUESCENT. (Not to be prescribed in cachets.)	EFFLORESCENT COMPOUNDS.
Ferrous: *Chlorid, bromid, iodid,* phosphate.	*Sulphate.*
Ferric: *Chlorid and scale compounds.*	Ferric alum.
Hyoscyamin: *Hydrochlorate, sulphate.*	
Lead:	Acetate.
Lithium: *Chlorid, bromid, iodid,* salicylate.	
Magnesium: *Chlorid, bromid, iodid,* citrate.	*Sulphate.*
Manganese: *Chlorid, bromid, iodid,* nitrate.	Sulphate.
Physostigmin: Sulphate.	
Pilocarpin: Hydrochlorate.	
Platinum: Chlorid.	
Potassium: *Salts generally.*	*Tartrate* (KNa), ferrocyanid.
Quinin: *Bisulphate, sulphate,* hydrochlorate, hydrobromate.	
Sodium: *Hypophosphite, hydrate,* haloids, nitrate.	*Carbonate.*
Spartein: Sulphate.	
Strontium: *Chlorid, bromid, iodid.*	Acetate, nitrate.
Strychnin:	Sulphate.
Zinc: *Chlorid, bromid, iodid,* nitrate.	*Acetate,* sulphate.

Granular effervescing and exsiccated salts, pepsin, codein, acid phosphates, glycerophosphates, piperazin, lysidin, dry vegetable extracts, and in general products desiccated *in vacuo.* Alkaline and ferro-alkaline iodids and aristols decompose with atmospheric O and stain capsules. Changes of deliquescence and efflorescence necessarily affect the dosage of drugs. Salts are more deliquescent in powdered than in crystalline form.

Color-changes. — Carbolic acid turns red (just as good—color removed by alcohol); resorcin, pinkish, yellow, or deep brown (especially if exposed even to traces of alkalies); apomorphin hydrochlorate, greenish (prevented by HCl); nitric acid, bromoform, aconitin, quinolin, santonin, and sodium santoninate, yellowish; cinchonin and cinchonidin salts and quinin salts, brownish; permanganate solutions, decolorized. All Ag salts, ferrous salts (from green to bluish or reddish brown), ferric scale compounds, iodoform, HgO, $Hg(CN)_2$ and HgI_2, HgI, pyrogallol, syrup of garlic, anilin, oleates, and chrysarobin darken from reduction or oxidation. HCN becomes brown, then black (paracyanogen) (prevented by a little HCl). Salicylates darken in the presence of the slightest trace of alkali. Acetanilid with spirit of nitrous ether develops slowly a yellow or red color. Osmic acid blackens in contact with organic matter. Sulphurated potash oxidizes from a liver color to green, then yellow ($K_2SO_3 + K_2S_7O_4$), and finally dirty white ($K_2SO_4 + K_2S_2O_3$). Syrup of HI is reduced by light, liberating free I, with brown or yellow color (specimen unfit to use if it turns starch-paper blue). Aqueous solutions of physostigmin readily decompose and turn red, and the alkaloid should not be exposed to the air. Adrenalin solution turns pink, then red and brown. Liquid plant products containing chlorophyl gradually turn brown, yellowish brown, or yellowish red.

Reduction.—Ammonium salts; synthetic iodin compounds (iodoform, aristol, europhen); chinolin, lead acetate, KCN; alkaline bi-salts; zinc acetate, iodid, phosphid, and valerianate. Ferric acetate, chlorid, and nitrate become basic and insoluble.

Oxidation.—Hypophosphites, nitrates, sulphids, sulphites, ferrous salts, pyrogallol, tannin solutions, P (spontaneous ignition), aldehyds (most alcoholics contain traces), all tend to darken, especially in the presence of alkalies. Amyl nitrite and aqueous solutions of chloral become acid. Terebene and terpenes become resinous and acid. $FeSO_4$ becomes coated with a brownish-yellow crust of basic ferric sulphate. Spirit of nitrous ether liberates free nitrous acid quickly in the light. Oleic acid becomes rancid. Mucilage of acacia turns sour and acid on standing, unless some preservative is used.

Labarraque's solution and H_2O_2 mutually reduce each other. Cantharides is very liable to deteriorate. The alkaloids of aconite are prone to decomposition by heat and by reagents. Ergot should not be used when more than a year old. Many volatile oils become terebinthinate on standing. The spontaneous decomposition of HgCl into $HgCl_2$, that sometimes takes place on exposure to light or air, can be detected by pouring water over the powder and immersing in the fluid a bright strip of copper or other metal. If any of the mercuric salt is present in solution, the metal will soon become tarnished.

Carbonation.—Lead acetate, lime, bleaching powder, KCN, and bicarbonates generally.

Evaporation.—Camphor, chloral, menthol, thymol, volatile oils, alcohols, and ethers.

Spontaneous combustion usually occurs in compounds containing, C, O, and Cl: Creosote and Ag_2O; $KMnO_4$ and glycerin or oxalic acid.

Precipitation.—Haskins states that the ppt. in liquor potassii arsenitis is due to the red saunders and excess of alkali. The ppt. in comp. syrup of hypophosphites consists of calcium citrate. Organic liquids, such as fluid extracts, often throw down on cold nights a ppt., which may or may not redissolve on warming and shaking. In the latter event the ppt. represents the insoluble part of a split-up product which can never be reconstructed. Sugar crystallization is liable to occur with many plant preparations in cold weather. A spirit made with absolute alcohol keeps better than samples made with weaker grades of alcohol.

Gelatinization.—Tinctures of kino, red gum and catechu, in particular, tend to gelatinize on standing, and so become worthless. $SnCl_4$ gelatinizes by forming the hydroxid.

Odor Changes.—If pure sugar is not employed in preparing syrup of Tolu, this acquires an unpleasant odor from splitting up of cinnamic acid and formation of acetylene. Old tinctures made with dilute alcohol are likely to have a stale smell.

PRACTICAL EXERCISES ON INCOMPATIBILITIES.

(Criticise and correct, if possible, and illustrate in test-tube or casserole.)

1. ℞ Acidi acet. dil., ʒij; spt. ammon. arom., ʒvj.

2. ℞ Argenti nitratis, gr. x; aquæ rosæ, ℥j.

3. ℞ Sodii salic., gr. xv; ammonii carb., gr. v; spt. ætheris nitrosi, ♏xv; spt. chloroformi, ♏x; aquam, ad ℥j.

4. ℞ Tinct. ferri chloridi, ʒij; quin. sulph., ʒj; tinct. cinchonæ, ℥ij.

5. ℞ Hydrogen. diox., ʒiv; potassii permang., ʒj; glycerin, ad ℥j.

6. ℞ Potassii chloratis, ʒj; tinct. ferri chloridi, ʒiv; glycerin, ad ℥ij.

7. ℞ Potassii iodidi, ʒij; strych. sulph., gr. ss; aquæ, ℥ij.

8. ℞ Liq. potassii arsenitis, ʒij; hydrarg. chloridi corros., gr. j; aquæ, ℥iv.

9. ℞ Hydrarg. bichloridi, gr. xx; sodii boratis, ʒij; aquæ, ℥iv.

10. ℞ Quin. sulph., ʒj; acidi sulph. arom., ʒj; potassii acetat., ʒiv; aquam, ad ℥iv.

11. ℞ Syrupi scillæ, ʒiv; spt. ammon. arom., ʒiv; aquæ, ℥j.

12. ℞ Zinci sulphatis, gr. ij; liquoris calcis, ℥j.

13. ℞ Liq. potassii arsenitis, ʒj; hydrarg. bichloridi, gr. ss; strych. sulph., gr. ¼; aquam, ad ℥ij.

14. ℞ Plumbi acetatis, ʒj; zinci sulphatis, gr. xx; alum. sulph., ʒj; aquæ, ℥j.

15. ℞ Acidi chromici, gr. xxx; glycerini, ʒiv.

16. ℞ Quin. sulph., ʒiss; tinct. ferri chloridi, ʒiij; ext. glycyrrhizæ fl., ʒj; aquam, ad ℥iv.

17. ℞ Spt. camphoræ, ℥ss; spt. chloroformi, ℥ss; aquæ menthæ pip., ℥j.

18. ℞ Hydrarg. chlor. mitis, ʒij; syr. rhei, aquæ, of each, ℥iss.

19. ℞ Tinct. guaiaci, ʒiv; sodii salicylatis, ʒij; aquam menthæ viridis, ad ℥ij.

20. ℞ Spt. menthæ pip., ʒij; tinct. capsici, ʒiv; aquam, ad ℥j.

21. ℞ Acidi nitrohydrochlorici, ʒiv; tinct. cardam. comp., ℥iss.

22. ℞ Sodii salic., ʒij; acidi hydrochlor., ʒj; aquam menthæ viridis, ad ℥ij.

23. ℞ Ammon. carb., ʒj; ammon. chloridi, gr. xxx; syrupi scillæ, ℥j; syrupi ipecac., ℥j; syrupi prun. Virg., ℥ij.

24. ℞ Tinct. ferri chloridi, ʒij; acidi carbolici, ʒss; glycerin, ad ℥j.

25. ℞ Collodii flex., tinct. iodi, aquæ ammoniæ, of each, ʒiv.

26. How combine tincture or fluid extract of cannabis Indica with an aqueous solution?

27. Explain the effervescence of spirit of nitrous ether with buchu or uva ursi.

28. Explain effervescence in making Dobell's solution.

29. Why is purified talc preferred to calcium phosphate or magnesia alba as a distributing agent for the preparation of aromatic waters?

30. Under what circumstances will spirit of nitrous ether give a brown color with iodids?

31. What causes the effervescence when glycerin, borax, and fluid extract of licorice are mixed together?

32. If a ppt. ensues on dissolving calcium hypophosphite in distilled water, what adulteration is present?

33. Why does quinin sulphate dissolve readily in tincture of iron?

34. Why does oil of wintergreen or oil of sweet birch give a deep violet color with ferric salts?

35. Why should syrup of senega keep better than the other official syrups?

36. How does H_3PO_4 clear up the dark color produced by adding tincture of iron to tincture of gentian?

37. Why should decoctions be prepared only in porcelain vessels?

38. Why does a mixture of potassium citrate, spirit of nitrous ether and water separate into two layers?

39. ℞ Iodoformi, ʒj; etheris sulph., ℥j; hydrogen. perox., ℥ij.

40. What causes the slow effervescence when bismuth subnitrate is put with a carbonate or subcarbonate in aqueous mixture?

41. Why does H_3PO_4 ppt. a solution of soluble phosphate of iron (ferric phosphate and sodium citrate in double compound)?

42. Why does a mixture of soap and calomel turn dark?

43. How does H_2O_2 added to a solution of hepar sulphuris render this milky?

SANITARY CHEMISTRY.

THE AIR.

AIR is contaminated by respiration, combustion, fermentation, putrefaction, and various trade and manufacturing processes. The CO_2 in the air should not exceed 6 parts in 10,000 when of respiratory origin; at this point vitiation is noticeable to the sense of smell. One pound of coal requires 240 cubic feet of air for complete combustion, and gives off 3 pounds of CO_2. One cubic foot of coal-gas combines with 5 to 8 cubic feet of air. A common gas-burner consumes about 4 cubic feet of air hourly and furnishes about 2 cubic feet of CO_2; 1200 cubic feet of fresh air is sufficient for every cubic foot of gas consumed. The vitiation of air from decomposing organic matter increases *pari passu* with the amount of CO_2; hence the latter is a measure of the former.

Experiment.—Test the CO_2 of the atmosphere quantitatively with decinormal oxalic-acid solution and lime-water: standardize 100 c.c. of latter with former, then take another 100 c.c. of the lime-water, shake in a bottle of known capacity, and titrate again with the decinormal solution. The difference in c.c. between the two titration readings = $Ca(HO)_2$ pptd. as $CaCO_3$. This difference × 0.0037 = weight of the hydrate changed to carbonate; and this product × $^{44}/_{74}$ = weight of CO_2 causing the change. By comparing the weight found of CO_2 with the weight of the same volume of air (1.29 gm. per liter) the actual proportion of the gas is determined. Simply stated, a liter of indoor air should not decolorize (from phenolphthalein) more than 1.3 c.c. of saturated lime-water after standing several hours.

Air containing an excess of CO_2 is detrimental to the health more from the coincident diminution of O and the concomitance of organic matter than on account of the CO_2 *per se;* as much as 10 per cent. has been borne when simply added to the respired air, whereas 8 per cent. of exhaled CO_2 causes death in a few minutes. A slight excess of CO_2 in sleeping-rooms leads to morning fatigue, headache, and drowsiness. Chronic CO_2 poisoning leads to anemia and debility and predisposes to infectious diseases, particularly phthisis. CO_2 is greatly increased in ground-air; O is diminished.

The proportion of water in indoor air varies greatly with local conditions, both within and without the house. Too little moisture causes a disagreeable dryness of the throat and fauces; too much predisposes to rheumatism and other diseases. One pound of fresh lime left in a room for twenty-four hours ought not to increase more than 1 per cent. in weight from absorption of water-vapor.

Hygrometry.—The percentage of moisture in the air relative to the dew-point (saturation) is estimated from the difference between dry-bulb and wet-bulb thermometric readings, the relation for different temperatures being given in tables. Other hygrometric methods are by means of the hygrometer (a copper spiral covered with prepared egg-skin or gelatinized or albuminized paper, together with a dial of percentages) and the use of cobalt chlorid papers, which turn from blue to red with moisture.

The most important impurities of the atmosphere include NH_3 (from stables, vaults, and animal exhalations); H_2S, NH_4HS, and CS_2 (from decomposition of substances containing S); SO_2 and mineral acids, especially nitrous and nitric (from combustion and electricity); amins, ptomains, and leucomains. H_2SO_3 in the atmosphere may make the rain acid, with destructive effect on mortar and soft building-stone. Sore throat and bronchitis are sometimes caused by leaking illuminating gas, soot, or H_2SO_3. Sewer gas in dilute form excites local irritation of eyes, nose and throat, headache, dullness, vertigo, and languor.

The organic matter from the skin and lungs consists of epithelia, fatty *débris*, and volatile fatty acids. These putrefy very quickly, giving rise to the bad smell of close rooms, and are absorbed by water and hygroscopic substances. This organic matter, reckoned as albuminoid ammonia (see "Water"), should not exceed 0.08 mg. per cubic meter.

Experiment.—Blow through a glass tube into Nessler's solution and show that NH_3 is present in exhaled air. Nessler's reagent is made by dissolving 35 gm. of KI in 100 c.c. of H_2O, and 17 gm. of $HgCl_2$ in 300 c.c. of H_2O; add first solution to second until ppt. at first formed nearly redissolves, and make up to a liter with 20 per cent. NaHO. The solution is improved by keeping; any deposit may be left in and the clear fluid above decanted as needed. It gives a yellow to brown color or ppt. with free ammonia.

A known volume of air may be sucked by an aspirator through a specially arranged apparatus containing ammonia-free distilled water, and the liquid then analyzed for free and albuminoid NH_3, like a water.

There is always in poorly ventilated houses a considerable quantity of animal and vegetable *débris* floating in the air, along with many varieties of germs, some of which are pathogenic.

Experiment.—Prove organic matter in exhalations by blowing into a very weak solution of $KMnO_4$ acidulated with H_2SO_4. The solution is decolorized.

Aitken has found that condensation of aqueous vapor requires the presence of dust in the atmosphere. By means of an ingenious mirror apparatus he has counted the number of particles of dust in a given space at various places and times. He estimates that ordinary still outdoor air contains from 1,000,000 to 5,000,000 particles per cubic inch; that of living-rooms, 20,000,000 to 100,000,000. The amount of matter suspended in the air is less after a rain- or snow-storm and in higher altitudes. The more dust, the more microbes in the air. By the time the air reaches the pulmonary vesicles it is usually sterile.

Most infectious diseases are propagated by the passage of germs through the air; hence the necessity of isolating and confining patients with such disorders. By proper ventilation deleterious substances in the air of rooms are greatly diluted, and the health of the occupants conserved. At least 400 cubic feet of space should be allowed for each healthy person in dormitories—two or three times as much for the sick.

An adult individual at rest (as in hospitals) should be supplied with 3000 cubic feet of fresh air per hour:—

$$\frac{3\times 0.4+0.6}{3}=0.6\ \mathrm{CO_2}\ \text{per } 1000,\text{—the limit of health.}$$

$$\mathrm{D}(\text{delivery})=\frac{\mathrm{E}(\text{amount of } \mathrm{CO_2} \text{ exhaled})}{\mathrm{r}(\text{respiratory impurity per cubic foot})}=\frac{0.6}{0.0002}=3000$$

cubic feet per hour; so that the respiratory impurity may not exceed 0.2 per 1000.

The vegetable and mineral matters inhaled by persons following certain occupations—as millers, bakers, textile workers, cutlers, lapidists, miners, quarrymen, stone-cutters, and potters—tend to irritate and produce disease of the lungs, especially emphysema, fibroid phthisis, and chronic interstitial pneumonia and pneumonokonioses. Poisoning from Pb, Hg, As, or brass may take place through the air.

The so-called noxious or offensive trades are those of boilers of blood, bones, tripe, or soap; tallow-melters, fellmongers, tanners, gut-scrapers, and glue-makers.

Acute mephitic poisoning from open foul drains and cesspools is characterized by sudden severe vomiting and purging, headache, acute prostration, and sometimes partial asphyxia. The long-continued inhalation of sewer-gas and drain-air produces gradual loss of health, with anemia, lassitude, headache, conjunctivitis, furuncles, sore throat, diarrhea, colic, nervous depression resembling typhoid, vomiting, and often fever. There may be sugar in the urine.

WATER.

Natural waters are more or less pure according to their source and course. For convenience they may be classified as potable (drinkable) and mineral, the latter being unfit for ordinary use, but presumably good for sick people.

Potable water includes that from rain, snow, ice, lakes, ponds, rivers, springs, wells, and cisterns. The purest natural water is that from snow falling on mountains. The latter part of a rain-fall or snow-fall is purer than the first part, as many impurities are by this time washed out of the air. Among the most common of these contaminations are NaCl, H_2SO_4, HNO_3, H_2S, SO_2, NH_4 salts, soot, mineral dust, and organic matter. Rain-water from roofs and that collected in large cisterns is notoriously unfit to drink, the contained organic matter undergoing putrefaction in a few days; the water from cisterns may also contain Pb. Na_2SO_4 is reduced by organic matter in marshy waters to sulphid (turns Fe in mud black), which reacts with CO_2 present to form Na_2CO_3. The humus acids in surface waters, generated in the bodies of earthworms, act on some rocks.

The usual source of hydrant-water is from ponds, lakes, and rivers: that is, surface-water. It is very important that no sewage enters the stream above the site whence the supply is drawn.

The relative purity of ice-water depends on its source. It is always purer than the water from which it was formed, but may still contain dangerous germs (typhoid, cholera) or their spores capable of originating deadly diseases. The flat taste of ice-water is due to the expulsion of dissolved gases in the process of freezing.

Spring-water and well-water are, in reality, nothing else than filtered rain-water containing an excess of CO_2 frequently, and considerable mineral matter which the CO_2 aids to dissolve. The sanitary condition of such waters depends on the depth of the excavation, the character of the soil and underlying strata, and the presence or absence of decaying organic matter in the area of drainage. Shallow wells are little more than cesspools when placed in the neighborhood of a barn or privy-vault. They drain, it is said, a cone of earth, the base of which has a radius equal to four times the depth of the well. The grossly polluted waters of many shallow wells are, as a rule, clear, sparkling, and palatable; but they quickly become turbid and putrid when kept in a bottle in a warm place.

Deep wells are one hundred feet or more in depth, or originate beneath a stratum of rock or impervious clay. These wells are safer than the shallow ones, especially if cased with metal, since the deleterious organic matter at or near the surface is pretty well destroyed by the time it filters down to the source of the well, but the water often contains an excess of mineral matter.

Artesian fountains are best of all wells, because the impervious stratum of clay that covers the water bed prevents access of decaying matter from the surface. Below 8 or 10 feet the filtered water no longer supports the life of micro-organisms (Holland).

Mineral waters, so called, are characterized by containing an unusual ingredient or an excessive amount of some ordinary constituent. According to the chemic nature of such ingredients, these waters are designated as saline (neutral salts), bitter ($MgSO_4$), acid (HCl and H_2SO_4), alkaline (carbonates and bicarbonates), chalybeate (ferrous sulphate, chlorid, or carbonate, held in solution by CO_2), silicated (siliceous acid), carbonated or effervescent (excess of CO_2 with bicarbonates), arsenical, bromo-iodin, alum, borax, and sulphureted (H_2S or alkaline sulphids) or hepatic. Waters that have a laxative effect ($MgSO_4$, Na_2SO_4) are termed aperient. Earthy mineral waters contain much of Ca and Mg carbonates and sulphates. Many mineral waters belong to more than one class. When the temperature of a spring is above 20° C. it is called a thermal spring.

Mineral waters are highly vaunted by persons who are interested financially. As a matter of fact, these waters have little, if any, more value than water *per se.* The strongest lithia-waters contain only a fraction of a dose in each gallon. In the case of the more common salts, their action is often neutralized and one danger substituted for another by the use of these waters, owing to the physiologic incompatibility of the various ingredients. Their ingestion *ad libitum* is particularly to be deprecated in organic heart disease.

Whatever good effects may accrue from the administration of mineral waters must be ascribed to the influence of suggestion, rest, and recreation, change of scene, and the action of water as water. It is far more rational for physicians to prescribe distilled water with the exact amount of each ingredient desired. The benefits derived in kidney and systemic diseases from baths at hot springs depend, not on any particular components of the water, but simply on the diaphoretic action of moist heat.

Sea-water contains an average of 3½ per cent. of minerals, chiefly $NaCl$ (2⅔ per cent.), $MgCl_2$, $MgSO_4$, KCl, and $CaSO_4$. It has a local tonic effect, which reacts on the internal organs, and the same is true of carbonated baths.

Water for drinking purposes should conform to the following conditions:—

1. It should be colorless, clear, and limpid. Turbidity may be due to either organic or inorganic impurities. A green coloration (in small quantities) indicates a high degree of vegetable contamination, and is comparatively harmless. Algæ and other micro-organisms may color red or greenish blue. A yellow or brown color may depend on animal matter or sewage, or less often on vegetable *débris* or iron. Dark-brown, globular masses usually originate in sewage.

2. It should be odorless. Odors may be brought out more distinctly by heating the water in a flask to a little more than blood-heat. Foul odors usually accompany sewer-gas, algæ, and putrefying organic matter. An odor like H_2S may be caused by the penetration of tree-roots, and is sometimes produced by

reduction of sulphates through the agency of putrefactive bacteria (bacillus sulphydrogenus).

3. It should be of agreeable taste: neither flat, salty, nor sweetish. A decided taste is commonly due to a high charge of mineral matter, especially iron and alkaline carbonates.

4. The most wholesome and desirable temperature is between 45° and 60° F. Warm storage water is apt to set up summer diarrhea in infants.

5. The quantity by volume of dissolved gases should be from 25 to 50 c.c. per liter of water. These gases are made up chiefly of O (1 per cent. volume), N (2 per cent. volume), and CO_2 (1 per cent. or more volume). The quantity of dissolved O is much diminished by excess of animal and vegetable matter, and this diminution (usually in still waters) is often accompanied by a bad smell and taste. Boiling water drives off the contained gases, giving rise to an insipid taste. The natural taste can be restored by aërating; for instance, by pouring from one vessel to another.

6. In hardness—that is, dissolved inorganic solids—good drinking-water should not exceed 40 grains to the gallon. Dyspepsia and diarrhea are caused by too much sulphates (above 7° or 8°) or by sewage (sometimes choleraic). It has long been held that hard waters are a causative factor in goiter. The mineral matter of hard water and the salt of brine tend to draw the juices out of meats and vegetables, and thus diminish their nutritive value and palatability.

7. Water fit for internal use obviously should contain no pathogenic germs, as of typhoid, cholera, dysentery, or anthrax. This is the most dangerous contamination to which drinking-water is subject. Well-water is more likely to cause enteric fever than is river-water, where saprophytic organisms destroy typhoid germs. Various entozoal diseases may also originate in the drinking-water.

Most river-waters contain Micrococci ureæ and butyric acid bacilli. Saprophytic organisms in running water eventually destroy typhoid bacilli and other pathogenic germs. The water from certain wells is stated to produce parenchymatous goiter.

PURIFICATION.

Various methods have been devised for purifying drinking-water for public and private consumption. The water-supply for cities is best clarified by allowing it to settle for 1 to 4 days in storage reservoirs, when it is drawn off onto filter-beds several feet in thickness, and composed mainly of coarse sand and layers of coke or crushed stone or gravel with a layer an inch deep of fine sand at the top. This layer of fine sand is the real filtering agent. It purifies water chiefly by condensation of O in its upper surface and the entanglement of bacteria in the superficial gelatinous deposit. It should be removed and washed frequently and thoroughly.

Another method in use on a large scale is scouring, or agitation and precipitation of solids, both mineral and organic, by the addition of 1 or 2 grains of alum to the gallon of water, thus forming a flocculent magma which carries down the silt and other suspended impurities as with a net. Free H_2SO_4 is sometimes evolved, or there may be failure to ppt. germs because of the lack of bases in the water. Lime-water may be used to ppt. excess of carbonates. Magnetic carbid-of-iron beds are also employed for purification on a large scale; these beds must be aërated occasionally to keep their oxidizing properties. Still another method is to pass the water through a revolving cylinder containing scrap-iron, and then through a trough, where the ppt. of ferric oxid carries down organic matter with it.

$CuSO_4$ (1 part to 100,000) is being used successfully for the purification of drinking-water. One part in 50,000,000 destroys algæ, to which a bad taste and odor are commonly due. Br (2 or 3 grains dissolved in one quart of infected water) destroys bacteria in five minutes. The Br can then be neutralized with NH_4OH or Na_2CO_3 (German method).

In London a living filter is employed for the water of the Thames. A layer of mud containing billions of innocuous saprophytes to the cubic foot is spread over the sand layer of the filter-bed, forming a jelly-like crust. These germs seize on all organic matter in the water, oxidizing and destroying it completely, thus affording the most efficient sanitary filter possible.

O is commonly spoken of as Nature's great antiseptic, yet in its ordinary molecular form it exerts this effect for the most part through the agency of microbes. The great majority of these are not only harmless, but of immense importance in the economy of Nature, requiring atmospheric O not only for their work, but for their very existence. Minute animalcules (infusoria, water-fleas) and fish aid in purifying water by feeding on nitrogenous matter in sewage.

All sorts of household filtering apparatus are in use. Among these may be mentioned brick partitions in cisterns, nests of asbestos, charcoal filters, and those of spongy iron, and silicated and manganous carbon blocks. The best filters probably for domestic use are made of unglazed porcelain (bisque) or fossil clay (compressed kieselguhr). The pores of these (Pasteur and Berkfeld) are so minute as not to permit the passage of micro-organisms.

Filters must be cleansed by immersing in water (boil for a half-hour every week; also bake in oven for 30 minutes every six months), as otherwise the germs in them multiply so rapidly as greatly to increase the dangers of pollution that these utensils are designed to prevent. In case of the slightest doubt as to the purity of any given drinking-water, the only safety lies in boiling or distilling it. Boiled water can be charged with air by means of a bellows. Faucet filters may be utilized for removing coarse suspended matters before boiling.

SANITARY ANALYSIS OF WATER.

The examination of drinking-water for practical hygienic purposes is accomplished chiefly by chemic tests: that is, indirectly for bacterial contamination. Typhoid bacilli have almost never been isolated from infected water, but colon bacilli are readily cultivated and signify animal contamination. The micro-organisms commonly found in stale water (algæ, cyclops, amebæ, rotiferæ) are harmless in themselves except as entozoa. Their presence in large numbers, however, points to an attendant pabulum of decomposing organic matter.

Color.—The color of water is best estimated by filling a 2-inch glass cylinder (closed at each end with a disk of colorless glass) with the water and holding it before an illuminated white surface, or looking down through the column on a piece of white paper beneath.

Reaction.—Water is normally faintly acid or alkaline. The reaction is tested with litmus, phenolphthalein (bleached by CO_2) or lacmoid (blue with alkalies, reddish-yellow with mineral acids—H_2SO_4—or ferric salts, unaffected by CO_2).

Total Solids.—The total residue left on evaporation and drying should not be more than 600 parts per million, or 40 grains to the gallon, though the amount has less significance in artesian water than in river-water. This sediment is ignited at a red heat and weighed again. The loss in weight represents organic and volatile matters; the remainder, mineral hardness. The said loss should never reach to 50 per cent. of the total residue. If on heating the first residue it blackens or fumes or smells like burning horn, we may be certain there is an excess of organic matter present.

Hardness.—This may also be determined by means of a standard soap solution, prepared by dissolving 10 gm. of Castile-soap shavings in a liter of alcohol (60 per cent.) and water (40 per cent.). Each c.c. of the solution represents 1 mg. of $CaCO_3$. The solution is added little by little to 100 c.c. of the water to be tested in a flask, and shaken. The addition is continued until the resulting lather remains appreciable for five minutes, and the degree of hardness readily noted from the number of c.c. used. When water contains less than 50 parts of mineral matter in 1,000,000, it is said to be soft; when more than 150, hard. The hardness of rain-water is generally less than ½ degree (½ grain per gallon). Parts per million are changed into grains per U. S. gallon by multiplying by the decimal 0.0583.

Chlorids.—An excess of chlorids (more than 15 parts Cl in 1,000,000) is generally (except in deep water or rain-water) an indication of the presence of sewage, particularly in localities at some distance from the ocean or salt-water lakes or wells. The amount of these salts (NaCl principally) is estimated by means of a standard solution of $AgNO_3$ containing 4.8 gm. of the latter to a liter of distilled water:—

$$\frac{AgNO_3}{170} \div \frac{Cl}{35.4} = 4.8$$

Each c.c. of the solution is equivalent to 0.001 gm. of Cl, or, if 100 c.c. of water be utilized for the test, each c.c. of the standard solution stands for 1 part of Cl in 100,000 of water.

Estimation of Chlorin.—Titrate 100 c.c. of water with standard $AgNO_3$ solution, using K_2CrO_4 as an indicator. $AgNO_3$ combines with the chlorids until they are used up, and then with the chromate, forming the orange-red chromate of silver. The reaction is at an end when the reddish color becomes permanent. The number of c.c. used of the standard solution corresponds to the parts in 100,000 of Cl.

Phosphates. — Phosphates, if present, are determined by slightly acidulating 500 c.c. of water with HNO_3, evaporating to 50 c.c., adding a few drops of dilute $FeCl_3$ and then slight excess of NH_4OH, filtering and dissolving residue in a little hot dilute HNO_3; the solution is evaporated, if need be, to 5 c.c., and to this 2 c.c. of $(NH_4)_2MoO_4$ is added, throwing down a yellow ppt. of phosphomolybdate of ammonium. More than 6 parts of phosphates [calculated as $Ca_3(PO_4)_2$] in 10,000,000 of water should be regarded with suspicion. Phosphatic rock dissolved by water is pptd. or removed by micro-organisms.

Organic Matter. — Waters showing a high O-consuming power are generally more unwholesome than others with a low affinity for O. A simple test for the O-consuming power of animal and vegetable impurities in drinking-water depends on the deoxidizing and decolorizing effect on $KMnO_4$ of organic products. Waters absorbing more than 2 parts O per million are of doubtful purity.

Experiment.—To a test-tube nearly filled with water add 2 per cent. of strong H_2SO_4 and then 5 drops of $KMnO_4$ solution, 0.300 gm. to the liter of distilled water. Boil for five minutes, when, if the purple color all disappears, organic matter is in excess of sanitary limits (more than 3 parts in 1,000,000).

The odors sometimes produced by heating the water residue (burning glue, hair, rancid fats, urine, etc.) should give rise to grave suspicion.

Ammonia. — The total N should not exceed 0.07 part in 1,000,000 (free, ¼; albuminoid, ¾). In the natural decomposition of organic substances by the O and saprophytes of the ground air NH_3 is one of the first products. NH_4 compounds may also be produced by reduction of nitrates and nitrites in presence of organic matter, especially in deep wells.

The reagent employed in testing for NH_3 is called Nessler's solution, and is an alkaline solution of HgI_2 prepared by the reaction between KI and $HgCl_2$ and NaHO (method of preparation under "Air"). This reagent gives a yellow or brown color with free NH_3, the depth of coloration varying with the amount of this gas present.

$$2HgI_2 + NH_3 = NHg_2I + 3HI$$

The test is a very delicate one, showing, it is said, 1 part of NH_3 in 100,000,000 of water. Albuminoid ammonia, or that present in combination in undecomposed organic matter, is separated from the other constituents by distilling with $KMnO_4$ and an alkali.

To determine the N of NH_4 compounds place in a glass retort, connected with a Liebig condenser and receiver, 200 c.c. of distilled water and 10 c.c. of a 25-per-cent. solution of Na_2CO_3 (ppts. Ca salts and frees NH_3), and distill until the distillate shows no reaction with Nessler's reagent. Then introduce 500 c.c. of the water under examination and continue distillation at the rate of about 50 c.c. every ten minutes. Add 2 c.c. of Nessler's reagent to each 50 c.c. of the distillate, collected separately, and compare color (fully developed in five minutes) with that of 50 c.c. of pure water containing some standard NH_4Cl solution (0.382 gm. dissolved in 100 c.c. of ammonia-free water, each c.c. being diluted for use with 99 c.c. of pure water — 1 c.c. = 0.00001 gm. N), to which 2 c.c. of the Nessler fluid is added.

According as the yellow-brown color of the standard mixture is deeper or lighter than that obtained from the water tested, other comparison liquids are prepared containing less or more NH_4Cl until the colors agree. Successive distillates of 50 c.c. are tested in the same way until no reaction occurs on nesslerizing. The sum of c.c. of diluted standard NH_4Cl required in making the color balances represents the number of hundredths of milligrams of N in the "free ammonia." A ppt. obtained by this method shows an excess of NH_3 beyond sanitary safety.

If the evolution of NH_4OH continues and increases up to the fourth or fifth distillate, it is probably due to the decomposition of urea or other nitrogenous substance, in which event this part of the process should cease and the next step (for albuminoid ammonia) be taken.

By "albuminoid ammonia" is understood the N of compounds convertible into NH_3 by alkaline potassium permanganate (8 gm. of $KMnO_4$ and 200 gm. of KHO dissolved in a liter of distilled water, boiled until one-fourth is evaporated, and then made up to a liter with ammonia-free water). The contents of the retort left from the first step are thrown out, the retort rinsed thoroughly, 200 c.c. of distilled water and 50 c.c. of permanganate solution introduced, and the mixture distilled down to about 100 c.c., nesslerizing the last portion of 50 c.c. to make sure that NH_3 is absent. Then add 500 c.c. of the water under examination and proceed with the distillation and nesslerizing just as for the free NH_3 in the first step. The difference between the free NH_3 of the first process and the total NH_3 of the second is the combined or albuminoid NH_3 present in the water.

Ammonia-free water for making these tests is prepared from distilled water, which often reacts with the Nessler fluid, by boiling down to three-fourths with a grain of Na_2CO_3 to the liter, or by distilling water slightly acidulated with H_2SO_4. Great care should be taken to prevent extraneous contamination, by rinsing thoroughly all the apparatus used.

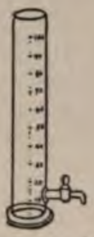

Fig. 57.—Cylinder for Nesslerization.

Nitrites and Nitrates. — The next step in the breaking down in the soil of organic matters into simpler substances is the conversion of NH_3 first into nitrites and then into nitrates. These changes can take place only by the aid of the nitrifying germs, which in the presence of mineral matters transform NH_3 into nitrites and nitrates of Na, K, and other metals at hand: salts which are the source of most of the N of plant-structure.

It is evident that nitrites in drinking-water are of less serious import than free NH_3, and that nitrates have a still less serious significance, showing less recent contamination. Unobjectionable subsoil-water from cretaceous strata may contain a proportion of nitrates inadmissible in the case of river-water. Nitrites are sometimes produced by reduction of nitrates by recent sewage, by metals, cement, or new brick-work. They are sometimes present in rain-water, and in deep-well water from lack of O to complete oxidation. It is stated that N as nitrites should not be above 0.001 part per million; N as nitrates, not more than 5 parts per million; but nitrates and nitrites are generally no longer regarded as serious evidence against the purity of water. In pure, deep-well waters containing soluble iron salts, a change of the iron to insoluble compounds causes formation of nitrites from nitrates if present.

Well-waters sometimes contain considerable mineral matter and suspended organic substance with but little or no nitrates, owing to a destructive fermentation.

Test for Nitrites.—Add 1 c.c. each of naphthylamin-hydrochlorate solution (10 gm. of b. naphthylamin and 10 c.c. concentrated HCl, with H_2O to make 250 c.c.) and of a saturated aqueous solution of sulphanilic acid to 100 c.c. of the water. A pink or red color shows that the water contains nitrites. This color, however, to be of sanitary significance, should appear within a very few minutes, as exposure to the air for a longer time causes a similar change, owing to absorption of nitrites from the atmosphere.

Test for Nitrates.—Evaporate in a suitable porcelain dish 50 c.c. of water to dryness, finishing the process over the water-bath. Next stir the residue thoroughly with 1 c.c. of phenol-disulphonic acid (made by mixing 3 gm. of phenol with 37 gm. of H_2SO_4 and heating for six hours in the water-bath) and dilute with about 25 c.c. of water; add NH_4OH in excess and make up the solution to 50 c.c. If nitrates are present, the yellow ammonium picrate is formed, varying in intensity with the amount present.

$$C_6H_4OHSO_3H + HNO_3 = C_6H_4OHNO_2 + H_2SO_4$$

The proportion of nitrates can be estimated by comparing a standard KNO_3 solution (0.722 gm. per liter; 1 c.c. = 0.0001 N), of which 1 c.c. is evaporated in a Pt basin, treated as above and made up to 50 c.c.

To draw deductions in slight degrees of pollution the normal standard of Cl, NH_3, etc., in the natural waters of the district must be known. The proportion of Cl in uncontaminated waters is fairly constant; when due to sewage it (and nitrates) is likely to undergo marked variations.

To distinguish between animal and vegetable water-contamination is a difficult matter. If the excess of organic matter is accompanied by excess of total solids, Cl, NH_3, nitrites, and nitrates (unless these have entered the water directly), the source of pollution is generally animal filth or sewage; when these conditions do not co-exist, the pollution is probably vegetable in origin. Decomposing nitrogenous matter yields NH_3 more rapidly on distilling with alkaline potassium permanganate than does non-decomposing matter. Water containing fermenting vegetable matter is colored yellow by boiling with Na_2CO_3, and nesslerizing the distillate gives a greenish tinge.

Biologic Test of Drinking Water (Holland).—Shake water well and add 1 c.c. to 99 c.c. of distilled water previously sterilized. Measure 1 c.c. of the diluted specimen in a sterile pipet, and mix with a tube of plating agar melted at 40°. Turn agar into a sterile 4-inch Petri dish and let solidify on a level table, then keep in an incubator at 22° for 96 hours and count number of colonies. The best waters show less than a hundred colonies in this way. The number of colonies times 100 represents approximately the number of individuals per c.c. of the water. Proper bacterial methods surpass the chemic in delicacy and in indicating sewage pollution. Illinois standard: The number of bacteria per c.c. is the number that will develop colonies on gelatin at 20°, and should not exceed 500.

Detection of Bacillus Coli Communis in Drinking Water (Holland).—Inoculate a Smith's tube filled with 2 per cent. glucose bouillon with 1 c.c. of water, and grow 24 hours at 38°. If no gas forms, colon bacilli are considered absent. If some gas forms, confirmatory tests should be used.

Neutral-red color in bouillon is reduced (changed to canary-yellow with green fluorescence) within 12 hours by the Bacillus coli, not by B. typhosus. It is also reduced by anaërobic bacteria (B. tetanus, B. anthracis, B. edemæ malig.), and is changed to a dull orange by B. mesentericus. Savage uses 0.1 c.c. of 0.5 per cent. aqueous solution of Grübler's neutral-red added to 10 c.c. of broth or agar containing 0.5 per cent. of glucose.

POISONOUS METALS.

The poisonous metals rarely or occasionally found in drinking-water include Ba and Cr (dye-works), Zn, As, Cu, Pb (dissolved by soft water or waters containing nitrites, nitrates, or excess of CO_2; also by humic, ulmic, and other peaty acids and by free H_2SO_4 formed by oxidation of iron pyrites). One-tenth grain of Pb to the gallon may produce plumbism. It is well to avoid water which has stood over night in the pipes. Mn, Fe (more than 3 or 4 parts in 1,000,000), and Al are also objectionable in notable quantities.

Ba is determined by slightly acidulating with HCl and adding solution of $CaSO_4$. Cr is found by evaporating a liter of the water to dryness with a little KNO_3 and $KClO_3$ and then fusing; any Cr is present in the residue as chromate, and on taking up with acid water gives a blue color with H_2O_2.

Zn is best detected by adding sufficient NH_4OH to render slightly alkaline, heating to boiling, filtering, and treating filtrate with a few drops of K_4FeCy_6. Reinsch's test is best for As, evaporating a liter of the water (rendered slightly alkaline with Na_2CO_3) nearly to dryness and acidulating with strong HCl. KSCN gives a blood-red color with ferric salts, or with ferrous after boiling with a few drops of HNO_3. H_2O_2 gives a brown ppt. with a concentrated water containing Mn.

Pb is found easily by adding to the water in a tall glass cylinder a drop of NH_4HS, giving a brownish-black ppt. of PbS, not cleared up by HCl (distinction from Fe) nor by KCN (distinction from Cu). The presence of the latter metal may be confirmed by adding K_4FeCy_6, getting a mahogany-red color. Water should not be drunk if it contains above $\frac{1}{20}$ gr. Pb or Cu, $\frac{1}{4}$ gr. Zn, $\frac{1}{2}$ gr. Fe per gallon, or the faintest trace of As.

FULL ANALYSIS OF MINERAL CONTENTS OF A SAMPLE OF ORDINARY POTABLE WATER (AFTER MUTER).

Step I. Take the total solid residue of 100 c.c. (calculated in grains per gallon) to serve as a check on the results; then ignite and again weigh: loss = organic and volatile matter.

Step II. Evaporate 2000 c.c. of the water to dryness in a large porcelain dish, and heat gently till fumes of NH_3 cease to be evolved.

Moisten residue with 10 c.c. of distilled water, and then add 200 c.c. of dilute alcohol; having gently detached it all from the dish, filter and wash with dilute alcohol till nothing more dissolves:

(*a*) The filtrate may contain all salts of K and Na, chlorids and nitrates of Ca and Mg, and the sulphate of Mg.

(*b*) The insoluble residue may contain the sulphate and carbonate of Ca and the carbonate of Mg, with any Fe and siliceous matter present.

(1) *Analysis of the filtrate.*

(*a*) Evaporate till spirit is driven off, cool, transfer to a 250 c.c. flask, and make up to the mark with distilled water. Divide into two portions of 100 c.c. and 150 c.c. respectively, marking them A and B.

(*b*) To A add NH_4Cl, NH_4HO and $(NH_4)_2C_2O_4$, to ppt. Ca. The ppt. is washed, dried, ignited, moistened with $(NH_4)_2CO_3$ solution, dried again and heated till no more fumes are evolved, then weighed as $CaCO_3$.

(*c*) To filtrate and washings from (*b*), concentrated to 50 c.c. and cooled, add Na_2HPO_4 to ppt. Mg. The ppt. is washed with a mixture of 1 vol. NH_4HO and 3 vol. H_2O, then dried, strongly ignited and weighed as $Mg_2P_2O_7$. If ppt. remains black after prolonged ignition, cool, moisten with HNO_3, dry and reignite. Calculate to MgO, and this times 2.5 = MgO present as Cl or NO_3 in the original 2000 c.c. of water.

(*d*) To B acidulate with HCl and add $BaCl_2$ to ppt. sulphate. Dry and weigh as $BaSO_4$. Calculate to SO_3, and this times $2.5 \div 1.5 =$ total SO_3 present in the original 2000 c.c. of water taken in combination with K or Na.

(*e*) The filtrate and washings from (*d*) are evaporated to a low bulk and rendered alkaline with pure $Ca(HO)_2$. To the filtered liquid excess of ammonium carbonate is added, the ppt. is filtered out, evaporated to dryness and gently heated as long as white ammoniacal fumes are visible. The residue must be purified by redissolving in water and adding a little ammonium carbonate, when a slight ppt. will form. After filtering, the fluid is evaporated in a tared Pt dish on the water-bath, and when dry the residue is gently heated to faint redness for a minute, cooled and weighed. Results $\times\ 2.5 \div 1.5 =$ total K and Na present in the 2000 c.c. of water started with.

(*f*) The residue from (*e*) is dissolved in a little water, and the K estimated thereon by $PtCl_4$ in excess. The whole is evaporated to dryness on a water-bath, and is then again digested with a few drops of $PtCl_4$ solution, and taken up with alcohol. The ppt. is collected on a weighed filter, washed with 80 per cent. alcohol till the washings appear quite colorless, dried at 100°, and weighed as $PtCl_4.2KCl$, and calculated to K_2O. An equivalent amount of KCl (calculated from this K_2O) is then deducted from residue (*e*), and the balance is NaCl, which is calculated to Na_2O.

(2) *Analysis of the insoluble portion.*

(*a*) This is washed from the filter with distilled water and then boiled with 100 c.c. of H_2O, and HCl added till effervescence ceases. Any insoluble is filtered out, washed with boiling water, dried, ignited, and weighed = siliceous matter in the 2000 c.c. of water started with.

(*b*) The filtrate and washings are warmed with a drop or two of HNO_3 and mixed with NH_4Cl and NH_4HO, and the iron estimated if present as Fe_2O_3, and result calculated to Fe = total Fe in the 2000 c.c. of water taken.

(*c*) Divide filtrate and washings into two equal parts, A and B.

(*d*) The portion A is pptd. with $(NH_4)_2C_2O_4$, and the Ca estimated as $CaCO_3$ as above, and calculated to CaO = total CaO as carbonate or sulphate in the original 2000 c.c. of water taken.

(*e*) The filtrate from (*d*) is concentrated to a low bulk, cooled, and Na_2HPO_4 added with excess of NH_4HO, and the Mg estimated (see

PLATE IV.

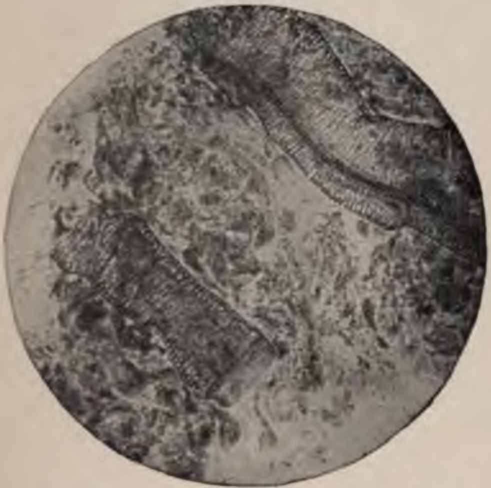

Fig. 1.—Adulterated Coffee, showing Vascular Ducts of Chicory.

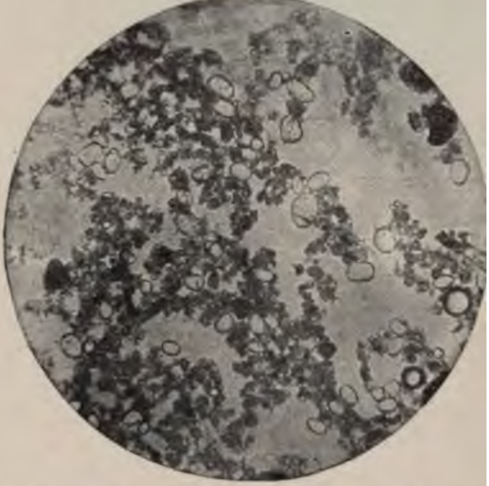

Fig. 2.—Adulterated Cocoa, showing Admixture o Arrowroot with Cocoa Powder.

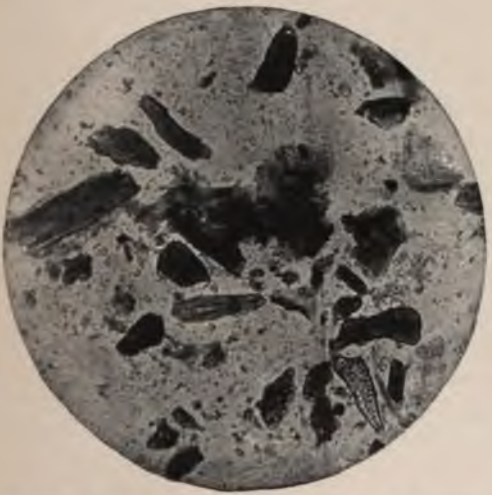

Fig. 3.—Adulterated Cloves, showing Chiefly Stone Cells of Cocoanut Shells.

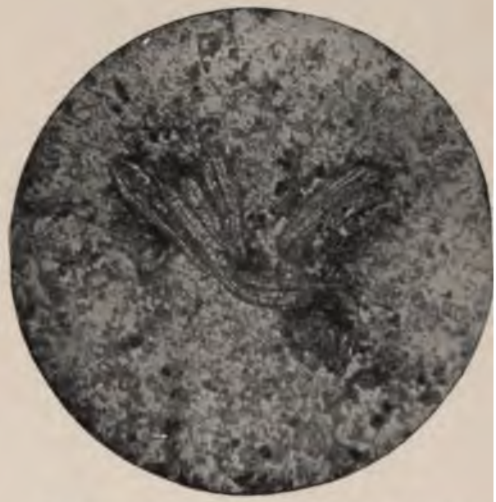

Fig. 4.—Adulterated Pepper, showing in center Sclerenchyma Cells of Olive Stones.

Plate Showing the Use of the Microscope in Detecting Food Adulteration.

Figures from Leach's "Food Inspection and Analysis." 1907.—New York, John Wiley & Sons.

above) as $Mg_2P_2O_7$ and calculated to MgO. Results × 2 = total Mg present as carbonate in the original 2000 c.c. of water.

(*f*) The portion B is acidulated with HCl, and the sulphate estimated by $BaCl_2$, weighed as $BaSO_4$ and calculated to SO_3. Result × 2 = total SO_3 in combination with Ca in the original 2000 c.c. of water.

Step III. Take the amount of chlorids as Cl volumetrically in 100 c.c. of water, as described under "Sanitary Analysis of Water." Result × 20 = Cl in 2000 c.c. of the water.

Step IV. *Calculation of results.*

Deduct from total of calculated oxids, Cl and silica an amount of O equivalent to the Cl found; *i.e.*, $^{16}/_{71}$ of the weight of Cl, since all the bases have been calculated to oxids, though O is not present in halogen salts. The difference between this remainder and the total residue left after driving off organic matter, represents CO_2. The actual combinations of bases and acids in a mineral water are somewhat hypothetic (aside from ionization) but the usual method is to consider that in the portion soluble in spirit SO_3 prefers the bases in the order of K, Na, Ca and Mg, while Cl will prefer the metals in the same order after the SO_3 is satisfied and used up. In the portion insoluble in spirit SO_3 prefers Ca to Mg, the remainder of these metals appearing as carbonates.

As to boiler waters, an approximate determination can be made by treating the total solids obtained by evaporation with 50 per cent. alcohol. The undissolved residue is dried and weighed as "scale-forming material."

FOOD ADULTERATIONS AND SOPHISTICATIONS.

Thanks to the deterrent effect of national and state laws on this subject, the adulteration of foods and beverages is much less common than it was a few years ago. Most of the practice nowadays is in the nature of sophistication—that is, the addition or substitution of comparatively harmless substances, which are injurious, however, from a negative standpoint, through deprivation of the displaced normal ingredients, and because of the impairment of the natural flavor upon which good appetite and digestion largely depend.

Water is sometimes added to lard up to 24 per cent., with the aid of lime or carbonate of sodium or potassium. Cheese in the curd stage is sometimes soaked in cold water to give more weight and a softer texture. "Renovated, process or hash" butter is prepared by heating and treating with sodium carbonate. Rennet or a mixture of pepsin and sodium sulphate, or gelatin and glucose, are added to butter ("stretched butter") to make it hold more water (up to 50 per cent.) and so increase its weight. "Refined or compound" lard is a mixture of beef fat and cottonseed-oil. Lard is also adulterated with starch, lime, alum, and salt. Oleomargarin is wholesome and nutritious, but is not so readily digested as butter, hence is contraindicated for invalids. "Butterine" has lard (40 per cent.) or commercial oleomargarin added to the milk and oleo-oil before churning.

Tests for Purity of Lard.—The m.p. of keg lard is about 33°; omental lard, 42-45°. On melting it should form a clear liquid, without scum or deposit. Added water now sinks to the bottom in a separate layer, and is estimated by heating a known weight of lard, with constant stirring, until it ceases to lose weight. Pure lard, on burning, should leave no ash.

Simple Tests for Butter (Leach).—The foam test consists in heating a small lump in a large spoon over the Bunsen flame, turned very low, stirring constantly during the heating. Genuine butter (butyric odor) will boil quietly, but with considerable froth, which will often swell up over the edge of the spoon when, just after boiling, the latter is raised from the flame. Renovated butter or oleomargarin (meaty odor) bumps and sputters noisily like hot grease containing water, but does not foam; on removing the spoon from the flame curdy particles are quite noticeable. With either pure or renovated butter the scale division of the critic line in Zeiss's butyrorefractometer when the melted sample begins to set is not above 54, whereas with oleo it reads higher. To distinguish azo-colors and annatto Doolittle recommends to dissolve 2 gm. melted, filtered fat in ether in each of two test-tubes. Into one test-tube pour 1 c.c. dilute HCl, and into the other 1 c.c. dilute KOH solution. Shake both tubes well and allow to stand. Azo-dyes show a pink to wine-red coloration with the acid test; no color with the alkaline. Annatto colors the potash solution yellow, and has no effect on the acid solution.

The substitution of oleomargarin for butter is readily detected by the marked difference in volatile fatty acids: nearly 8 per cent. in the case of butter and only about ½ per cent. in oleomargarin. A mixture of butter, oleomargarin, and cocoanut-oil may have the same proportions of insoluble acids as butter, and is distinguished by the oleorefractometer. The sp. gr. of butter (at 100° F.) is rarely below 0.91; of beef-fat, never above 0.9018. The m.p. of butter is from 86° to 94° F.; of beef-fat, rarely above 82° F.

Test for Butter (Leffmann).—Wash a 300 c.c. flask thoroughly; rinse with alcohol, then ether; dry by heating in water-oven, cool, and weigh. Introduce 5.75 c.c. of the sample measured by means of a pipet heated to about 60°, and after fifteen minutes weigh again. Then add 20 c.c. of glycerol-soda solution (1 part of 100 per cent. NaHO solution with 9 parts of pure glycerin) and heat over the Bunsen flame until complete saponification takes place (in about fifteen minutes). Dissolve the soap in 135 c.c. of water, gradually added with shaking, and add 5 c.c. of 20 per cent., by volume, H_2SO_4; drop in a piece of pumice, and distill until 110 c.c. have been collected. If the distillate is not clear, it should be thoroughly mixed and filtered, and 100 c.c. of the filtrate taken. Standardize with decinormal alkali in the usual way; if only 100 c.c. of distillate are taken, the findings should be increased by $\frac{1}{10}$. A blank experiment should be made to determine the amount of standard alkali required for the materials (seldom above 0.5 c.c. for good glycerol). Five gm. of butter yields a distillate requiring from 24 to 34 c.c. of decinormal alkali to neutralize; commercial oleomargarin (usually churned with milk), 1 to 2 c.c. of the alkali. Butter-fat is readily and completely soluble in ether; beef-fat leaves a residue.

Skimming milk increases the sp. gr. and diminishes the cream. Milk which has been both skimmed and watered may have a normal sp. gr., but is thin and blue. Mechanically separated milk contains only 0.1-0.3 per cent. of fat; skim milk, 0.8-1 per cent. The bacteria (lactic-acid bacillus and others) in badly kept milk may amount to 3,000,000 or 4,000,000 per c.c., and are the active cause of the summer complaint of infants. Milk is also very liable to bear the germs of enteric and scarlet fevers, diphtheria, tuberculosis, and foot-and-mouth disease; also the mold of thrush *(Oïdium albicans)*. The best preventives of milk-infection are cleanliness in milking and in the care of cows, and keeping the milk on ice from the time it is drawn until ready to be used. Bacteria may be filtered out to a considerable degree through cotton.

Test for Formalin.—Add a few drops of dilute phenol to the milk, and pour the mixture on strong H_2SO_4, getting a bright-red ring. An orange coloration is noted with pure milk.

Or float a mixture of equal parts of milk and water on H_2SO_4 made yellow with $Fe_2(SO_4)_3$ (commercial H_2SO_4 contains a trace); formalinized milk shows a blue to violet ring (pure milk greenish); this test shows as little as 1 part in 250,000.

Leach's Test for Formalin in Milk.—Heat about 10 c.c. of the milk with an equal quantity of conc. HCl and a drop of $FeCl_3$ solution. A violet color shows the presence of HCOH, even to the extent of only 1 part in 300,000. As a negative test this one is especially delicate.

Detection of Borax or Boric Acid in Milk (Leach).—Add to the ash 1 or 2 c.c. of dilute HCl, then dissolve in a few c.c. of water from wash-bottle. Soak a strip of turmeric paper for a minute or so in the solution. A positive reaction is shown by the paper on drying turning a deep cherry-red, changed to dark olive on treating with dilute alkali.

Test for H_2O_2 in Milk (Arnold and Mentzel).—Add to 10 c.c. of the specimen 10 drops of a 1 per cent. solution of vanadic acid in dilute H_2SO_4. A red coloration shows as low as $\frac{1}{100}$ of 1 per cent. of this preservative.

Test for Gelatin in Cream or Ice-cream (Stokes).—Dissolve Hg in twice its weight of HNO_3 (1.42) and dilute with 24 times as much water by volume. To 10 c.c. of this solution add as much cream and about 20 c.c. of cold water. Shake the mixture vigorously, let stand 5 minutes and filter. To the filtrate (cloudy if much gelatin) add an equal volume of saturated aqueous solution of picric acid. A yellow ppt. shows the presence of as little gelatin as 1 part in 10,000.

Test for Annatto.—Coagulate 1 ounce milk with a few drops of $HC_2H_3O_2$, heat, strain, press out excess of liquid; triturate curd in a mortar with ether; decant ether and add to it 10 c.c. of a 1 per cent. solution of NaHO, shake and allow to separate; pour off upper layer into a porcelain dish, put in a small strip of filter-paper, and evaporate gently. The strip is colored buff or orange, turning pink with $SnCl_2$.

Skimmed milk cheeses are seldom "filled" nowadays with lard, cottonseed and other oils, since such sophisticated products lack the natural aroma and flavor. Olive-oil is very extensively adulterated, especially with cottonseed-oil (sometimes with peanut or sesame). There is no objection to this from the hygienic or dietetic point of view, but it is nevertheless a fraud, and must be stopped. Almond-oil is often adulterated with the poisonous oils of peach and apricot kernels. Menhaden, whale, and seal oils are used to adulterate cod-liver oil.

Test for Cottonseed-oil (Halphen). — Mix in a test-tube equal volumes of the oil to be tested, amyl alcohol, and CS_2 containing 1 per cent. S in solution. Keep tube (loosely stoppered with cotton) in boiling brine for 15 minutes, when a red coloration appears if oleum gossypii seminis is present.

Differentiation of Food Oils (Harrington).—If 12 c.c. of a suspected sample are mixed in a test-tube with 5 c.c. of a 2.5 per cent. solution of $AgNO_3$ in 95 per cent. alcohol, and placed in a beaker of boiling water, the following color changes ensue: Olive, greenish; cottonseed, black; sesame, dark reddish-brown; peanut, reddish-brown, then greenish and turbid; poppy, greenish-yellow.

Starch is a very common "filling" agent (increases weight and capacity for water) in potted beef and poultry, patés, sausages (prevents shrinkage when fried), yeast, baking powders (up to 50 per cent.—should not exceed 20 per cent.), ground mustard and canned corn (renders liquid more creamy). "Lemon jelly" may be made from starch and tartaric acid. Potato starch is often mixed with sago. Extract of yeast is sometimes found in meat extracts. Wheat flour is rarely adulterated with cornmeal and other cereals. "Buckwheat" flour is not seldom a mixture of rye, maize, wheat, etc. Gluten flours are often over half starch. The amount of water in bread should not generally exceed 40 per cent. (up to 50 per cent. when quite fresh). Alum is normally present in flour and bread to the extent of 6 to 10 grains in a 4-pound loaf.

Testing Purity of Flour.—According to Vogel, 70 per cent. alcohol containing 5 per cent. HCl remains colorless after being used to extract pure wheat or rye flour. It turns pale yellow if oats or barley be present; orange-yellow, if mixed with pea flour. Sophistication with potatoes shows increase of water and an alkaline ash. Unbleached flour shaken with petroleum ether colors this fluid light yellow; bleached flour causes no change in color.

Cane-sugar is sometimes added to honey and to Indian corn, which is lacking in sweetness. Much more objectionable is the use of saccharin in corn and tomatoes. Jellies and jams are often nothing more than glucose, gelatin, and starch paste flavored with essential oils and colored with anilin dyes. Apple stock (pulp, skins, seeds, and cores), pumpkins, turnips, and molasses are the common basis for all kinds of jelly sold in stores. Glucose is also a leading component of imitation honey, maple syrup, and fruit butters. Glucose is only half as sweet as cane-sugar, but it is not injurious to health, except as it may contain sulphuric and sulphurous acids, used in its manufacture and not completely removed. Cheap confectionery is composed largely of glucose and starch colored with anilin dyes. The use of paraffin in butterscotch and chocolates is dangerous, because of its insolubility.

Sugars and Syrups.—Standard brewers' sugar is hydrous starch sugar containing not less than 70 per cent. dextrose, nor more than 6 per cent. ash; climax, or acme, sugar, 80 per cent. and 1.5 per cent. respectively. Anhydrous grape sugar should contain not less than 96 per cent. dextrose, nor more than 0.6 per cent. ash (chlorids and sulphates of Na and Ca). Granulated, loaf, cut, milled and powdered sugars should contain at least 99.5 per cent. of sucrose. Added ultramarine is decomposed by HCl, showing the blue color. Glucose gives a much higher polarimetric reading than cane molasses, and on inversion continues to read to the right almost as high as before. Glucose, or corn syrup, should show no more than 25 per cent. water or 3 per cent. ash. Syrup deposits an unsightly ppt. on standing if ultramarine blue has been added.

Identification of Honey.—If honey gives a ppt. when treated with excess of alcohol, the dextrin of commercial glucose is present. All genuine honey contains grains of pollen. When fermented with yeast, not more than 5 per cent. (corn syrup 15 to 20 per cent.) of unfermentable matter should be left. $BaCl_2$ ppts. the trace of H_2SO_4 in corn syrup. Honey is neutral or levorotatory (rarely a few degrees to right); corn syrup and saccharose are dextrorotatory. To distinguish properly adjusted inverted cane-sugar from pure honey, convert to ash—the ash of genuine honey contains about 0.03 per cent. H_3PO_4, the substitute none.

Test for Saccharin.—Extract 50 c.c. of sample, acidulated with 25 per cent. H_2SO_4, with a mixture of equal parts of ether and petroleum spirit, and evaporate solvent at a gentle heat. The sweet residue is heated with 2 c.c. of saturated NaHO solution until mass fuses for one-half hour, when saccharin is changed to salicylic acid. If the latter was originally present, it may be separated by dissolving the ether residue in 50 c.c. dilute HCl, adding Br water in excess, shaking well, and filtering off the brominated salicylic acid.

Maple Products; Color Test (Sy).—Put 15 c.c. syrup or 15 gm. sugar and water to make 15 c.c. into a test-tube or narrow cylinder, add 1 c.c. 20 per cent. H_3PO_4; mix thoroughly by shaking; let stand until alcohol separates, and note its color—pure products always give a decided brown—adulterated samples, from a trace of color to a light brown—cane-sugar products colored with caramel give no color to the alcohol. *Foam Test.* Place 5 c.c. of syrup in a narrow tube or cylinder graduated in 0.1 c.c.; add 10 c.c. of water and shake vigorously for one-half minute; let stand 10 minutes and read volume of foam in c.c.; pure products give from 3 to 6 c.c. foam—adulterated or mixed products always below 3 c.c. *Malic Acid Value.* Place 5 c.c. of syrup or 5 gm. sugar and water to make 5 c.c. in a 25 c.c. measuring cylinder; add 10 c.c. water and 2 c.c. solution of lead subacetate; mix thoroughly and allow to stand 20 hours, then read volume of settled ppt. For pure maple products this is over 3 c.c. (usually over 5 c.c.); adulterated samples give much less ppt., corresponding with amount of pure maple present in sample. Sugar-cane syrup may give a heavy lead ppt. The presence of "mapleine," says Hiltner, is shown by invert sugar above 5 per cent. ("mapleine" contains about 20 per cent.) and ash below 4 per cent.

Foreign mineral contamination, accidental or surreptitious, is usually negligible in quantity. Actual dirt is sometimes left purposely in truffles. One seldom encounters of late ground gypsum, talc, terra alba, silicates, marble or chalk in confectionery or flour; iron or brass filings, soapstone, gypsum or sand in tea; lead salts and iron oxid in cocoa; or sand in sugar. Arsenic (from iron pyrites used in making sulphuric acid, for manufacturing glucose) is an occasional dangerous, even fatal, contaminant of beer and soda-water. Lead compounds have been added to wines to sweeten the product. Tin, lead and zinc, from can and solder, may accidentally contaminate canned meats, fish, and fruits. Varnishing the inside of the cans prevents electrolytic solution of the metals. "Terne" tin plate contains a mixture of tin and lead, and is used for roofing, and sometimes wrongly for cans. A trace of zinc is sometimes found in dried apples, from the use of galvanized iron racks. Molasses should hardly be considered an edible substance, since it contains tin chlorid, zinc salts and sulphurous acid used in refining the sugar of which it is the residue. Solutions containing copper, lead, mercury or arsenic have been applied to the outside of cheeses to preserve them from insects. The "bloom" of lime on nutmegs answers the same purpose.

According to Wiley, the basic sulphate of aluminum is the acid ingredient in the great majority of present-day baking powders. He says that if the proportion to baking soda is properly balanced, the powder leaves on reaction aluminum hydrate (not ordinary alum) and the sulphates of sodium, potassium or ammonium (ammonium carbonate sometimes used as alkaline agent). Alum baking powders have no noticeable effect on the health, but yeast bread is probably more hygienic than that prepared with these powders. Alum is sometimes added to baker's bread to render it hygroscopic and whiter and prevent souring. It may also be found in pickles and ground ginger.

Test for Alum in Bread.—Its presence in any quantity can be detected by pouring a fresh infusion of logwood (made with distilled water) over the flour or bread. The color of the logwood is changed to lavender or violet-gray. This test gives a distinct bluish color with 0.02 per cent. of alum, but several other mineral substances yield a somewhat similar reaction.

Ground spices are commonly sophisticated with fruit stones, hulls and shells, flour, starches, cereals, ground shipbread, charcoal, sawdust, clay, gypsum and cheaper spices. Whole ginger is sometimes "whitewashed" with chalk or plaster of Paris, or bleached with chlorinated lime or sulphurous acid. Ginger, previously exhausted by the ginger-beer manufacturers, is often sold as genuine. Whole black mustard is frequently mixed with rapeseed. Pepper may contain a large proportion of sand and other mineral matter. Unground pepper berries are sometimes weighted by saturating with brine, or whitened by bleaching or facing with chalk. Cayenne pepper is at times weighted with red lead. One of the most dangerous and reprehensible forms of adulteration is the use of wood alcohol in cheap flavoring extracts. "Lemon extract" is sometimes made from the oil of lemon grass. "Vanilla extract" is often prepared from the tonka bean or coumarin.

Simple Tests for Spices, Extracts and Beverages.—Roasted coffee floats for some time on water; roasted chicory quickly sinks. It is moist to the touch, and forms clinging masses which color water dark brown on shaking. Cloves that have been subjected to distillation float on water; the official buds sink. Vanilla extract should contain from 2 to 4 per cent. of total solids (gums, resins, etc.). On heating vanilla extract, if tonka or coumarin is also present, an odor like tobacco is noted. The oil of lemon extract is readily thrown out of solution, and measured centrifugally or otherwise, by treating with a few drops of HCl and considerable excess of water. Artificial nutmegs are easily broken into a powder when treated with boiling water. Pepper berries should sink quickly in water. Long pepper, a wild Indian grass, has a disagreeable odor and imparts a slatey color to samples containing it. The presence of starch (wholly absent from pure mustard) is shown chemically by stirring with water, heating and adding tinct. iodin, getting a blue or green color. When strong NH_4OH is poured on mustard containing turmeric, the mixture turns orange-red. Naphthalene yellow can be extracted with strong alcohol; it dyes wool a bright yellow.

Mineral acids in vinegar are detected by adding a solution of methyl-violet, which turns blue with mineral, not with organic acids. The ash of cider vinegar gives a decided indication of K salts; that of molasses vinegar, no K but much Ca salts and the odor of rum. Substitutes for cider vinegar show slight or no reaction for malic acid—should yield a rather copious ppt. with solution of lead subacetate.

Tea leaves are heated and exposed to the air (oxidation and fermentation); longer in the case of black tea than of green tea. Many kinds of tea are artificially scented by admixture or by roasting with foreign leaves, which are then removed. The natural aroma is due chiefly to the yellow volatile oil developed by roasting and drying. Borax and sodium carbonate are sometimes added to improve the color of the infusion. The soluble ash in genuine leaves is 3 or 4 per cent. Exhausted leaves yield too low a soluble ash. A high total ash indicates iron or brass filings or sand (insoluble in HCl). Mn is a normal ingredient. Chocolate is often defatted by heat and pressure for making cocoa and other preparations. Cocoa and chocolate have been adulterated with vegetable oils, mutton tallow, clay, brick dust, and Venetian red. So-called soluble cocoas are prepared with sugars and starches, particularly arrowroot. Alkalies (high ash) are sometimes added to form an emulsifying soap. Ground coffee is commonly sophisticated with the darker, more bitter chicory, which itself is sometimes adulterated with beets, mangel wurzel, dandelions, oak-bark, sawdust, and colored earths. Spent coffee beans are rarely roasted with sugar and sold as genuine. Artificial "coffees" are made by roasting wheat, oats, and other cereals. True coffee contains no starch.

Many are the deceptive names of food preparations. "Full cream" cheese means simply cheese made from the whole milk. "Peach" ice-cream is soured vanilla cream flavored with lemon. "Egg powders" for making cakes consists of colored casein or starches. "Raspberry sauce" is sometimes created almost wholly from gelatin. "Guernsey brandy" is a spirit made from beet roots artificially flavored. Baking powders should be specified as alum, phosphate and tartrate, since the leavening power of the first variety is much below that of the other two.

A frequent form of simple fraud is misnaming a natural product as to its geographic origin, *e.g.*, the Maine herring sold as the European sardine.

Horseflesh and other meats of uncertain origin are occasionally utilized in sausages. Most pernicious of all is the practice of selling passé cold storage products (particularly eggs and undrawn poultry) as strictly fresh. After long periods the deterioration of meat and poultry is very marked, and poisonous degradation compounds may be formed by autolysis. The same is true of the borax-preserved broken eggs used by bakers. Beginning putrefaction may be detected by holding a rod, dipped in a mixture of 1 c.c. each of ether and HCl and 3 c.c. of alcohol, over the suspected matter, producing fumes of NH_4Cl. Preserved meat often turns slimy from the peptonizing action of aërobic bacteria on its surface.

A very frequent kind of adulteration is the addition of coloring matters and other substances to "improve" the appearance or taste. Such "improvement" is deceptive, and panders to a semi-barbaric taste for high colors and flavors. The natural colors in cochineal, burnt sugar, annatto, saffron and chlorophyl are considered harmless, but only a few anilin dyes have escaped condemnation by experts. There have been several deaths in young children from eating the concentrated colors. These dyes may contain arsenic or mercury, used as oxidizers in their manufacture. The coal-tar dyes are cheap and are used very extensively in confectionery (chlorophyl, eosin and cochineal), ice-cream, jams, jellies, wines, sausages, mince meat (also carmine), pie fillers and maraschino cherries. Practically all butter is artificially colored, sometimes with marigold, turmeric, saffron or annatto; often with coal-tar dyes, especially methyl-orange and carotin. If it is really desirable for butter to have a rich yellow tinge, this can be accomplished in a natural way by feeding the cows carrots, ruta-bagas, yellow maize, and clover hay. Cheese is colored with carrot-juice, saffron, annatto, turmeric and yellow azo dyes. Naphtol-yellow is used in cakes. Curcuma is commonly added as a coloring agent to ground ginger, mustard, and rhubarb. Gelatin and caramel are sometimes put into milk or cream to make them look richer. "Viscogen" is a syrup of lime (6½ per cent.) used to give body to creams.

Detection of Caramel (Crampton and Simons).—Mix the liquid by vigorous shaking with one-third its volume of fuller's earth, let stand for a half hour and filter. Liquors, vanilla extract, etc., colored with caramel are largely decolorized.

Test for Turmeric.—Shake the food sample with alcohol or chloroform, filter and treat filter-paper (after drying) with solution of borax slightly acidulated with HCl, getting a rose-red color, which turns dark green on adding ammonia.

Detection of Coal-Tar Colors.—In general coal-tar colors give a second dyeing to white woolen cloth in a slightly acid medium (after decolorizing with NH_4HO, then acidulating this fluid with HCl). Artificial vegetable dyes in weak solution turn violet on standing over night after treating with excess of NH_4HO. Anilin dyes can be shown in wines by shaking together equal volumes of wine and ether in a flask and letting stand to separate; the ether shows a red coloration if the test is positive. Fuchsin in confectionery can be found by shaking the neutral solution with a mixture of equal parts of ether and amyl alcohol, which is colored red or pink on separating. Eosins are fluorescent. Azo-colors on treating with a mixture of 90 per cent. alcohol and 10 per cent. HCl, and moistening filter-paper, turn this rose-red on drying.

Mineral coloring matters are much more objectionable than vegetable. The oxids and salts of arsenic, copper, chromium, and lead are especially injurious, and have been found in confectionery, flour, cakes, and cheese. Copper sulphate and nickel salts give an intense green color to cucumber pickles and canned peas which are imported into this country. Stannous chlorid precipitates the coloring matters from syrups and gives a bright yellow appearance. Tea leaves may be faced with lead salts or Prussian blue.

Bleaching agents in food are of hygienic importance. Sulphurous acid (the fumes of burning sulphur) is used with dried fruits, starches, wines, and finished sugars (may contain salts of tin or ultramarine blue). Bisulphite of sodium or potassium is used with canned corn. Inferior flour is sometimes bleached by electrically generated ozone and oxids of nitrogen. Saponin is sometimes added to soda-water syrups to give a good foam. It may cause gastritis. "Soaked, or floated," oysters look plump, but have lost flavor and may be infected from the water or ice used.

Imitation maple syrups are made of extract of hickory bark ("mapleine") with glucose or cane syrup. Synthetic imitation fruit flavors and syrups are commonly utilized for cakes and ices. Sauces are sometimes rendered piquant with sulphuric acid. Alcoholics and poisonous flavors (oil of mirbane) are not permissible in candies.

Alcoholic liquors are often adulterated, *e.g.*, beer with quassia, gentian, columbo, chiretta, chamomile, kino, cream of tartar, copperas, orris root, picric acid, strychnin, picrotoxin, wormwood, capsicum, cinnamon, ginger, and other spices. Sodium bicarbonate is used in beer to correct acidity and increase the bead. Glycerin sweetens the beverage and gives it body. Poisonous fusel-oil is present in excess in young raw whisky.

Cheap wines are made from raisins, dried apples, raspberries, and gooseberries. Champagne has been made from gooseberries and water. Gin is often concocted from a mixture of water, sugar, cinnamon, alum, capsicum, cream of tartar, and a little alcohol. Prune-juice is frequently added to factitious and fictitious rum. Alum heightens the color of wines; added acids imitate the reaction of mellow age. Cheap wines are often "plastered" with calcium sulphate, which preserves the product and improves the color by forming an acid sulphate of potassium and separating out tartrate of potassium.

Simple Tests for Alcoholic Liquors.—Basic lead acetate and a little ammonia ppt. all the bitter substance of hops, but not of strychnin or picrotoxin. Added glycerin in beer is detected by the acrid vapors on incinerating residue after evaporation. Fusel oil in spirits is best detected by its odor on evaporating slowly on the water-bath. Added ethers (Molnar's test) may be shown by evaporating a little whisky or brandy with excess of KHO; on adding excess of H_2SO_4 to the residue, the volatile acids, with characteristic odors, are liberated. To detect foreign colors in wines, treat 50 c.c. of the wine with 1 c.c. formalin and 4 c.c. conc. HCl, and heat mixture in water-bath until ppt. forms. The solution is then made alkaline with ammonia, all excess of which is expelled by further heating in the water-bath. Cool and filter. With natural wines the filtrate is colorless, but with artificially colored wines the color remains. Whisky containing neutral spirit and colored, when mixed with an equal part of fusel oil throws down artificial color; true whisky does not show this reaction.

Test for Picric Acid.—Evaporate ½ to 1 liter of beer to dryness on water-bath; treat with alcohol, filter, and evaporate filtrate; dissolve residue in boiling water and evaporate again; extract residue with ether, which dissolves the acid and on evaporation leaves it as yellow needles giving a blood-red color with KCN (isopurpuric acid).

The question of the use of chemic preservatives in food has long been a storm center of controversy between sanitarians and manufacturers. Dr. H. W. Wiley, the foremost authority upon this subject, declares that nearly all food preservatives (including borax, boric acid, sodium sulphite and benzoic acid), used continually, have a deleterious effect upon digestion and are irritating to the kidneys. He holds that sterilization suffices for canned fresh meat, and that grain spirit and the simple condimental substances (salt, sugar, spices, vinegar, wood smoke) in moderate quantities are the only unobjectionable added preservatives. One important objection to food preservatives is the stale condition which they hide, though not preventing the formation of autolytic enzymic products detrimental to health.

Borax and boric acid have been extensively used in milk, cream, butter, meats, beef-juice, broken eggs (two to four pounds of borax per 100), and oysters.

Sodium sulphite and saltpeter are added to meats to preserve the red tint of the fresh article. A recent U. S. food inspection decision permits the presence of 350 mg. of sulphur dioxid (not over 70 mg. free) per liter in wines and molasses. Glycerin is used to preserve beef-juice and bone-marrow. In large amounts it may have a hemolytic action, as shown by the urine. Benzoic acid or sodium benzoate is frequently added to meats, fruit juices, catsups, jams, jellies, and fruit butter. In viands like catsup, necessarily exposed to the air some time after opening, sodium benzoate is generally considered still permissible in the proportion not to exceed 1 part in 1000. Salicylic acid, hitherto used in fruit juices, jams, jellies, milk, wines, beer and catsups, is now rightly prohibited. Abrastol (asaprol), $Ca(C_{10}H_6SO_3OH)_2$, a beta-naphtol derivative, is said to have been used as an antiseptic in wines, jellies, etc. Sodium fluorid, in bottled beers, may cause chronic poisoning marked by general bone pains and a tendency to thrombosis.

A most reprehensible practice, now fortunately disappearing, is the addition of formaldehyd ("freezine, iceline, preservaline, milk sweet") to milk, wines, broken eggs, and "shucked" oysters. It hardens the casein of milk and renders it less digestible, and irritates the alimentary tract and the kidneys, even producing hematuria.

Test for Salicylic Acid.—Render 25 to 50 c.c. of sample feebly acid with H_2SO_4 and shake thoroughly with an equal volume of a mixture of equal parts of ether and petroleum spirit. Allow to separate in a funnel, and draw off the solvent, filter, and evaporate gently. The needle-like crystals of salicylic acid dissolved in a little water give a violet color with $FeCl_3$. Benzoic is converted into salicylic acid by boiling the sample with acetic acid, filtering, treating filtrate with H_2O_2, and extracting with ether.

Detection of Saltpeter.—A dilute solution of diphenylamin in H_2SO_4 is a delicate reagent, giving with the dry residue a deep blue color with traces of any nitrate.

Detection of Sulphurous Acid or Sulphites (Leach).—Mix 100 gm. of the sample (finely macerated in a mortar if necessary) with enough water to form a thin solution or paste. Acidify with H_3PO_4 and distill off 20 to 30 c.c.; treat distillate with a few drops of Br water, and boil; then add $BaCl_2$ solution. A ppt. indicates sulphurous acid or sulphites.

U. S. FOOD STANDARDS.

(M stands for maximum, and m for minimum per cents.)

Meat extract—solids 75 m, ash 27 M, fat 0.6 M, N 8 m, bases 40 m.
Meat-juice—ash 15 M, N 12 m, P_2O_5 2 to 4.
Lard—substances not fats or fatty acids 1 M; leaf I no. 60 M.
Milk—3.25 fat m, solids not fat 8.5 m.
Condensed milk—fat 7.7 m, total solids 28 m.
Cream—fat 18 m.
Butter—water 16 M, milk fat 82.5 m.
Cheese—fat 50 m.
Ice-cream—fat 14 m (fruit and nut 12 m).
Flour—water 13.5 M, ash 1 M, N 1.25 m, vegetable fiber 0.5 M.
Gluten flour—moisture 10 M, N 5.6 m.
Cornmeal—moisture 14 M, ash 1.6 M, N 1.12 m.
Oatmeal—moisture 12 M, ash 2.2 M, N 2.24 m, fiber 1.5 M.
Rye flour—moisture 13.5 M, ash 1.25 M, N 1.36 m.
Buckwheat flour—moisture 12 M, ash 1.75 M, N 1.28 m.
Maple sugar—ash 0.65 m.
Molasses—water 25 M, ash 5 M (treacle or refiners' syrup 8 M).
Sugar-cane or sorghum syrup—water 30 M, ash 2.5 M.
Maple syrup—water 32 M, ash 0.45 m.
Sugar syrup—water 35 M.
Honey—water 25 M, ash 0.25 M, sucrose 8 M, levorotatory.
Allspice[1]—ash 6 M, fiber 25 M, quercitannic acid 8 m.
Cayenne pepper—ash 6.5 M, fiber 28 M, starch 1.5 M, nonvol. ether extract 15 m.
Ground cinnamon—ash 6 M, sand 2 M.
Cloves—ash 8 M, fiber 10 M, quercitannic acid 12 m, vol. ether extract 10 m.
Ginger—lime 1 M, ash 6 M, fiber 8 M, starch 42 m.
Mace—ash 3 M, fiber 10 M, nonvolatile ether extract 20 to 30.
Ground mustard—ash 8 M, starch 2.5 M.

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[1] The ash of spices insoluble in HCl should not exceed 0.5 per cent., except ginger (3) and black pepper (2).

Prepared mustard—protein 35 m, fiber 12 M, carbohydrates 24 M.

Nutmeg—ash 5 M, fiber 10 M, nonvolatile ether extract 25 m.

Black pepper—ash 7 M, fiber 15 M, starch 15 m, extract 6 m (N 3.25 m).

White pepper—ash 4 M, fiber 5 M, starch 50 m, extract 6 m (N 4 m).

Almond extract—oil of bitter almond 1 m.

Lemon extract—oil 5 m; terpeneless = citral 0.2 m—dextrorotatory.

Vanilla extract—soluble matter of at least 10 per cent. vanilla beans.

Tea—ash 4 to 7.

Roasted coffee—ash 3 m, fat 10 m.

Chocolate—ash 3 M, fat 45 m, fiber 3.5 M, starch 9 m.

Apple cider—ash 0.24-0.6 (one half K_2CO_3), total sugars 6 to 20, sp. gr. 1.0415-1.069, levorotatory.

Grape juice—ash 0.2-0.55 (P_2O_5 largely), sugars 7-28, sp. gr. 1.04-1.124.

Cider vinegar—apple solids 1.6 m, ash 0.25 m (P_2O_5), acetic acid 4 m.

Evaporated apples—water 27 M.

Jam, marmalade, preserve—45 or more fruit to 55 sugar.

Table salt—$CaSO_4$ 1.4 M, $CaCl_2$ and $MgCl_2$ 0.5 M, insoluble 0.1 M.

DRUG IMPURITIES.

Arsenic and tellurates are frequently present in bismuth salts (bismuth breath), Na_2HPO_4, and many other salts. Most mercurous salts contain traces of the corresponding mercuric salts. Crude sublimed S often contains As and other impurities. FeS_2 is often found in reduced iron; H_2S is evolved on treating with acids. Bromates in alkaline bromids liberate free Br on adding dilute H_2SO_4. Iodates in iodids liberate free I in contact with mineral acids. Bi in Hg is readily detected by shaking Hg in a test-tube, when the Bi separates as a black powder. Common salt commonly contains some $MgCl_2$. Hypophosphites often contain an excess of sulphates. Cream of tartar is often adulterated with starch, alum, and acid calcium phosphate; less often with chalk, calcium sulphate, and potassium acid sulphate. The best baking-powders should yield about 12 per cent., by weight, of gas, but many yield much less.

Compound spirit of ether contains a little free H_2SO_3. Gums are notoriously impure, often containing dirt, sticks, bark, and pebbles. Digitalis is often substituted by mullein-leaves and elecampane-leaves; saffron with calendula; senna with argels. Carthamus (safflower) is often substituted for saffron.

Spanish saffron is increased in weight by coating the stigmas with colored $CaCO_3$. "Venice turpentine" usually consists of a mixture of resins with oil of turpentine; "Burgundy pitch," of melted resin and fat, with sufficient water to render turbid. Balsam copaibæ is commonly adulterated with East India wood-oil and paraffin- or vaselin- oil. Essential oils are very commonly sophisticated: oil of rose with Indian grass-oil. Olive-oil is commonly adulterated with oil of cottonseed, walnut, sesame, poppy, rape, or peanut; cod-liver oil with porpoise, shark-liver, and other cheap fish-oils. When shaken in a test-tube with an equal volume of nitric acid pure olive-oil should show a green coloration; cottonseed, a red color. Cacao-butter is adulterated with tallow, lard, stearic acid, paraffin, beeswax, and cocoanut and arachis oils. Imitation beeswax is sometimes made from tallow hardened with spermaceti and carefully colored. Gelatin is commonly substituted for isinglass.

All crude drugs (especially cinchona and cannabis Indica) vary greatly in the content of active principles. A purple color is produced on heating powdered cinchona in a test-tube if sufficient alkaloids are present. In the United States Pharmacopeia will be found many practical tests for chemic impurities, both qualitative and quantitative, the latter being chiefly volumetric for the permissible limit of impurities.

Purity of Volatile Oils.—To test for alcohol in volatile oils, shake with an equal quantity of water and let stand to separate. If alcohol is present, the watery layer will be increased. Fatty or mineral oils are shown by their insolubility in alcohol. Turpentine is detected in other essential oils by adding a drop of H_2SO_4 to 5 drops of the oil, getting a dark-red color.

Test for Sandalwood-oil.—If to 1 c.c. of the oil there is added 10 c.c. of a mixture of 3 volumes alcohol and 1 volume water, a perfectly clear solution should be obtained, excluding castor, cedar or birch oil.

Test for Purity of Rhubarb.—Powdered rhubarb is often adulterated with turmeric, which is detected by percolating with chloroform, dropping percolate on borax and drying, then moistening with HCl, getting an orange color.

Test for Purity of Balsam of Peru.—Gurgun balsam as an impurity is shown by adding CS_2, getting a cloudy, fluorescent mixture, which gelatinizes on heating to 130°.

To Detect Rosin in Beeswax.—Dissolve the specimen in boiling 0.5 per cent. soda solution, and add excess of dilute HCl, getting a ppt.

ANTISEPTICS AND DISINFECTANTS.

A disinfectant or germicide is "an agent capable of destroying the infective power of infectious material": that is, specific germs. An antiseptic retards or arrests bacterial growth and toxin formation; it may or may not be germicidal. A deodorant is an agent that absorbs or oxidizes offensive odors; it is rarely germicidal. Antizymotics prevent fermentation and putrefaction.

The removal of any and every kind of dirt and filth is essential to the proper office of these agents. Since perfect asepsis is impossible, antisepsis must often be added to cleanliness. Disinfection, in general, depends upon (1) heat, (2) oxidation, (3) sunlight or actinism, (4) reduction, (5) coagulation, and (6) direct toxic action upon bacteria.

Of all disinfectants, the most efficient is moist heat, to which, at the temperature of boiling water, all pathogenic bacteria and their spores succumb within five minutes. Stained goods should first be soaked in cold water. For sterilizing instruments for an operation nothing is better than boiling them for at least five minutes in pure water, to which 2 per cent. of Na_2CO_3 may be added to cleanse adherent grease and prevent rusting. Gauze and other dressings should be sterilized by steam heat just previous to being used. Steam apparatus is essential for bulky matters, such as bedding, carpets, and clothing. Dry heat is not nearly so effective as moist heat, and when necessary to resort to this method it should be applied at about 300° F. and fractionally—that is, for a short time on successive days—in order to destroy any spores that may have resisted the heat and developed into germs. Boiling decomposes cocain and atropin solutions.

Antiseptics and disinfectants act much more powerfully in warm water than in cold. The tubercle bacillus is killed in 10 minutes in water at 70°; 5 minutes in boiling water. It resists dry heat at 100° for several hours. Some bacteria withstand freezing in liquid air, and may retain their vitality for months at 20 inches below the surface of the soil, which is the level of maximum bacterial contamination; the soil becomes sterile at 4 yards beneath the surface. True antiseptics, says Roger, possess the very curious property of stimulating the chromogenic and other functions of bacteria when employed in minute quantities. Strong, irritant germicides and antiseptics favor suppuration. Antiseptic dusting powders act mainly by lessening secretion, decomposing ptomains and stimulating leucocytosis.

Acetanilid. — This remedy in powdered form is used by many physicians as a local antiseptic, particularly in the treatment of chancroids. Like other coal-tar preparations, it may give rise to depression and cyanosis.

Alcohol.—The antiseptic properties of alcohol depend on its dehydrating and coagulating effects, by which the germs are deprived of the moisture necessary to their growth and are also acted upon directly as to their waxy capsules. It is sometimes used as an intra-uterine injection in cases of puerperal fever. Alcohol preserves alkaloidal solutions. Dilute alcohol is more actively germicidal than pure alcohol.

Benzoic Acid.—This acid is not to be classed as a germicide, but has sufficient inhibitory activity (1 to 900) to prevent the rancid decomposition of animal fats, and hence is much used in ointments. Internally in doses of 10 to 30 grains benzoic acid is a serviceable antiseptic remedy in chronic cystitis. Benzoate of sodium is an oxidizing antiseptic.

Boric Acid.—It is inhibitory rather than germicidal. A 1 to 133 solution arrests the activity of most bacteria. It is free from irritating or toxic qualities and from disagreeable taste or odor. A saturated solution (4 per cent.) is commonly employed for the sterilization of mucous surfaces, and is a good deodorizer in cases of fetid perspiration. A 1-per-cent. lotion is used extensively for preventive purposes in cleansing the mouth, nose, and eyes of infants as well as the nipples of the mother. Boric acid is frequently added to alkaloidal solutions, to forestall decomposition. Insufflations of the dry powder into the auditory canal after cleansing the latter are generally rapidly curative in suppuration of the middle ear. The too free use of boric acid as a surgical dressing may give rise to dry throat, vomiting, diarrhea, sleeplessness, depression, dim vision, headache, erythema, urticaria, and even collapse and death. Its prolonged use has led to scaly skin diseases.

Borax is also slightly antiseptic, and in saturated solution (12 per cent.) has yielded good results in the various forms of tinea. The glycerite of boroglycerin is made some use of as an antiseptic vehicle for alkaloids and glucosids in the local treatment of skin and eye diseases.

Bromin.—Like the other members of the halogen group, this element is a disinfectant and deodorizer of great power. Over 6000 pounds of Br were used at Johnstown, Pa., after the great flood in 1889. The highly corrosive nature of the liquid and the irritating character of the fumes which it evolves make its employment out of the question in the operating-room and in the sick-chamber. The bromids are also antiseptic, NaBr in 10-per-cent. solution being destructive to the germs of cholera and typhoid.

Carbolic Acid.—The disinfectant properties of phenol were first recognized by Chaumette in 1815, but it was not until 1867 that the new era of surgery was inaugurated by Lister in his memorable communication on the merits of this drug. The disinfectant potency of phenol is well established. Generally speaking, we may be certain of reliable antiseptic results with a 5-per-cent. solution of the acid, though certain bacteria and many kinds of spores resist its action in any strength. In this strength it is much employed to sterilize instruments, particularly those that would be injured by heat. A 2-per-cent. solution is used as a wash. A solution of 6 ounces to one gallon of water is a good disinfectant for infected stools and cloths. Carbolized soap solution is 3 per cent. soft soap and 5 per cent. commercial phenol in water. According to Yersin, a 1-per-cent. solution will destroy tubercular bacilli in one minute. Carbolates and sulphocarbolates are much weaker.

Carbolic acid coagulates albumin with facility. It can act in the presence of sebaceous and oily matters. It is an effective local anesthetic, and is sufficiently soluble in the common solvents. The chief objection to carbolic acid is liability to systemic poisoning, manifested by smoky urine, pain in the lumbar region, dyspnea, and possibly collapse. It also benumbs and corrodes the hands and dulls the instruments of the operator. Even weak solutions have caused gangrene. Phenol should not be employed upon children. The former use of the carbolic spray during operations rested on the faulty supposition that infection took place through the atmosphere rather than by way of the hands, dressings, and instruments. The attempts at disinfection of a sick-room with vapors of carbolic acid or similar compounds are equally illogical and futile. A few drops of liquid phenol, to each ounce of an alkaloidal solution, serve as an effective preservative.

Chloral Hydrate.—A 5-per-cent. lotion has been used with satisfaction in the treatment of foul ulcers and parasitic skin affections. It is also employed as a deodorant in the urinals of paralytic patients.

Chlorin.—The disinfectant value of this element has been recognized since its discovery by Scheele in 1774. It has a great affinity for H, which it takes from H_2O, setting free the powerful germicide nascent O. Hence the necessity for moisture in the use of this agent. Cl also acts as a deodorizer by taking away the H of sewer-gas. Nissen determined that a solution of ½- to 1-per-cent. strength destroys the germs of typhoid and of cholera within five minutes.

Cl for disinfecting purposes is derived almost exclusively from calx chlorata, the so-called chlorid of lime, which evolves the gas gradually in the presence of moisture. It should contain at least 25 per cent. of available Cl. Chlorinated lime is altogether the most suitable substance for deodorizing drains, sinks, water-closets, and infants' diapers, and for disinfecting alvine evacuations and other discharges. For the latter purpose the fresh powder should be used in the proportion of a half-pound to the gallon. It ought always to be placed in the vessel before depositing the excretions therein. It is also a good disinfectant for sputum.

Common salt and $ZnCl_2$ are inimical to all low forms of life. Of the former, a saturated solution, says Miquel, will kill cholera spirilla in a few minutes. The latter compound is antiseptic in the strength of 1 to 25. A 10-per-cent. lotion is a serviceable caustic application for foul ulcers.

Chloroform.—This well-known anesthetic prevents fermentation due to micro-organisms, while it does not impede the function of the unorganized digestive ferments. Water and spirit of chloroform are therefore efficacious remedies in digestive disorders attended with fermentation and flatulence. A drop of chloroform to each ounce of liquid is perhaps the best preservative for urine and alkaloidal solutions.

Chromic Trioxid.—Koch asserts that CrO_3 is markedly germicidal, and Miquel claims that it is antiseptic in a 1 to 5000 solution. The drug is, however, very irritating and caustic, and death has ensued from its too free application.

Citric Acid.—A solution 1 to 200 in strength will kill the spirilla of cholera on a half-hour's exposure; hence the benefits from drinking lemonade in times of cholera and other water-borne infections.

Copper Sulphate. — In 5-per-cent. solutions this salt is a powerful disinfectant (coagulates albumin) and an absorbent of H_2S and ammonia.

Creolin.—A 2- to 5-per-cent. emulsion with water is sometimes used for vaginal injections, and stronger mixtures are employed for general disinfection. Lysol, solveol and solutol, are similar mixtures of cresols, and are freely soluble in water, owing to their saponaceous character.

Creosote.—Beech-wood creosote, in spite of its irritating properties, is still widely employed as an intestinal antifermentative and digestive stimulant, particularly in tuberculous cases. Creosote is related to phenol, and is apt, when used in excess, to produce analogous symptoms of systemic poisoning, such as headache, stupor, and smoky urine. Schill and Fisher found that a 1-per-cent. solution of creosote failed in twenty-four hours to kill the tubercle bacillus.

Cyanid of Zinc and Mercury. — This insoluble compound has been used to some extent in the form of gauze for surgical dressings. It is feebly germicidal, strongly antiseptic, and non-irritating, but extremely poisonous, on which account its use should be condemned.

Ether.—Ethylic ether in full strength is an efficient germicide. Its chief use in surgery, however, aside from anesthesia, is to dissolve and remove the fatty matters of the skin before applying antiseptic solutions. It is employed for the same purpose in the preparation of surgeon's catgut.

Eucalyptol.—This is a camphor-like substance credited by Behring with an antiseptic potency one-fourth that of carbolic acid, and depending largely on the aldehyd aromadendral. The eucalyptus preparations are indicated in chronic urinary diseases associated with decomposition of urine within the body.

Ferrous Sulphate.—Copperas is not a germicide, but has weak antiseptic properties, and in strong solutions is of service as a deodorizer for vaults and other damp places.

Formaldehyd.—The marked efficiency of this gas was discovered by Trillat and Aronson in 1892. A 1-per-cent. solution destroys nearly all germs in less than thirty minutes. The gas is an admirable surface disinfectant, but has not the penetrating power of SO_2. Its germicidal power is probably due to the fact that it renders albuminoids insoluble in water. It is the best remedy for smut and potato scab (soak seed potatoes).

For disinfecting rooms the gas may be produced by heating solid paraformaldehyd over an alcohol-lamp; or it can be developed directly by oxidation of methyl alcohol, the vapors of which are made to pass through heated metal tubes or coils. Another method, recommended by Novy, is to heat formalin

(40-per-cent. aqueous solution) containing 10 per cent. of glycerin or a little $CaCl_2$ (dehydrates gas); or by dipping sheets in a weak formalin solution and hanging them upon lines in the room. The walls, ceilings, and other surfaces may be sprayed with 1:1000 formalin.

To liberate formaldehyd quickly and effectively, pour 2 parts of 40-per-cent. solution (formalin) upon 1 part of crystals of $KMnO_4$—or one pint of formalin (24 oz. below 60° F.), poured over 6¾ oz. potassium permanganate in an asbestos-lined vessel, for every 1000 cubic feet of space.

As HCOH is quite diffusible, all apertures of the room should be kept tightly closed for six or eight hours while the gas is operating. Its irritating odor is quickly dispelled by evaporating some NH_4OH in the room. For thorough disinfection it is well also to wash the furniture with antiseptic solutions, to rub the wall with bread-crumbs, to scrub the floor thoroughly, and to boil all the clothes and bedding that can be treated in this way. For surgical use formaldehyd is utilized in ¼- to ½-per-cent. solutions; for general antisepsis, ½- to 2-per-cent. solutions; and for sterilizing catgut, a 4-per-cent. solution. Like $HgCl_2$, formalin roughens and hardens the hands. Paraform pastils are very convenient for sterilizing catheters by keeping them together in a closed box. A few drops of formalin, placed in the clinic thermometer case every fortnight, serve as an efficient sterilizer.

Glycerin.—Copeman discovered in 1891 that glycerin is able to sterilize vaccine pulp sufficiently for clinical purposes, without affecting the properties of the unknown vaccinia germ, and glycerinated lymph, preserved in sterile capillary tubes, is at present a most convenient and acceptable form of vaccine. At least 33 per cent. of glycerin must be present to prevent development of pus cocci. It has no effect on the tetanus germ or toxin.

Iodoform.—The clinic benefits accruing from the application of CHI_3 depend mainly on starving the germs by absorption of local secretions and on chemic changes in the toxins. In the presence of much moisture diiodoacetylid is also evolved, and aids in the approximate sterilization of the tissues. Some micro-organisms grow in iodoform, and prudence dictates that the drug should be itself sterilized by heat before using it. A 10-per-cent. solution in olive-oil is especially valuable for injection in tuberculous affections of the joints.

The immoderate use of iodoform as an application to fresh wounds is a matter to be deprecated, since alarming toxic symptoms may follow: such as erythema or eczema and painful swelling about the wound; headache; faintness; prostration; high fever; rapid, feeble pulse; collapse; amblyopia, and cerebral phases simulating meningitis. The pupils are contracted. Elderly persons and children are especially susceptible to the deleterious influence of the drug. $KHCO_3$ may be used as an antidote locally and by the mouth. Chronic iodoform poisoning is manifested by anorexia, indigestion, vertigo, insomnia, eczema, rapid pulse, fever, and amblyopia. The invincible odor of CHI_3 is very offensive to sensitive patients. Cumarin covers the odor somewhat. Tincture of iodin, applied to cleansed contused wounds, prevents suppuration. A 2 per cent. aqueous solution (with 4 per cent. KI) was Senn's favorite antiseptic application.

Lactic Acid. — Although the product of alimentary fermentation, this acid, in larger quantity, inhibits fermentative changes. Kitasato states that a 4 to 1000 solution is destructive to typhoid bacilli.

Lime.—Fresh CaO is a strong germicide, 1 to 1000 being sufficient to destroy cholera and typhoid germs. It is used mainly for disinfecting manure-heaps and privy-ordure. As a fertilizer it accelerates the decomposition of organic substances in composts.

Mercuric Chlorid.—The reign of corrosive sublimate as an antiseptic began in 1881, when Koch affirmed its generally germicidal action in solutions as weak as 1 to 15,000. A 1 to 1000 solution is needed for non-spore-bearing bacteria; 1 to 500 for the spore-bearers. Abbott has ascertained that a 1 to 500 solution will not destroy pus-cocci even in the absence of spores. It has been demonstrated by a number of observers that the action of strong solutions of $HgCl_2$ is not germicidal, but inhibitory, and that when the chemical is pptd. from the germs they again resume their vital functions. The citric or tartaric acid in bichlorid tablets aids the penetration of the antiseptic into the tissues. The antiseptic power of a solution of $HgCl_2$ is considerably diminished by the addition of NaCl (teaspoonful to quart of solution, to prevent precipitation) on the general principle that, when to a solution containing free ions similar ions are added, there is a tendency to reform the original molecules. A solution of $HgCl_2$ in ether or absolute alcohol has no effect on germs, since in this medium the mercuric salt is not dissociated. The cyanid of Hg is less germicidal than the bichlorid, since the former ionizes little if at all.

The principal objections to the use of $HgCl_2$ as an antiseptic are as follows: It is irritating to the tissues, even causing necrosis. Strong solutions roughen the hands. If absorbed to the extent of a grain or more, it is apt to produce alarming toxic symptoms. It combines with albumin, forming an insoluble and inert (while undissolved) compound; nor can it act in the presence of fat or soap. In aqueous solution it is quite unstable, tending to reduction into calomel. It is very corrosive to instruments. Despite the above disadvantages, $HgCl_2$ remains the favorite antiseptic of a large proportion of physicians and surgeons. That such should be the case shows merely that a dictum, once established, is difficult to overthrow.

Mineral Acids.—Hydrochloric, nitric, and sulphuric acids have each slight antiseptic energy. The first named has supplanted lactic acid in the treatment of ordinary stomachic indigestion.

Mustard. — A solution of the oil of black mustard only 1 to 33,000 is capable of preventing the development of anthrax-spores. All the essential oils have more or less antiseptic power.

Naphtalin. — Naphthalene is utilized as a prophylactic against moths. Beta-naphtol is sometimes administered as an intestinal antiseptic. It is liable to be contaminated with its poisonous isomer, alpha-naphtol. The derivative hydronaphtol is also prescribed as an intestinal disinfectant.

Oxygen.—Despite the popular belief to the contrary, ordinary molecular O is not directly germicidal except in the case of the relatively rare anaërobic bacteria. It is the freshly liberated or nascent atomic form of the gas which is a true and powerful germicide. Whatever merits ozone may possess as a disinfectant are due to breaking up of the gas into nascent O and the ordinary form. The good effects derived from the use of wood-charcoal in fermentative disorders depend largely, no doubt, on the O occluded in its pores, as well as on absorption of the abnormal gaseous products.

Petroleum.—Crude petroleum and kerosene have come into extensive use of late for destroying the larvæ of yellow-fever- and malaria- bearing mosquitoes. The oil is spread on the surface of pools infested by these insects.

Potassium Permanganate. — This is an efficient oxidizing germicide. The tubercle bacillus is the only common pathogenic germ which withstands the action of a 5-per-cent. solution. The drug is not adapted to internal administration, since it is quite irritating to the stomach; in the presence of readily combustible substances it has sometimes exploded. According to Weir Mitchell, it is the most efficacious local antidote for snake-bite.

$KMnO_4$ has of late years risen to prominence as a disinfectant for the surgeon's hands. The method, introduced by Kelly, consists of three steps: first, scrubbing the arms, hands, and nails thoroughly with soap and hot water; second, immersion of the parts in a saturated solution of permanganate; third, washing off the K salt with a saturated aqueous solution of oxalic acid until the purple color has all been removed. Oxalic acid itself is a strong antiseptic, and so reinforces the action of the permanganate. The resulting itching of the skin, if annoying, may be relieved by bathing with sterilized lime-water, also an antiseptic.

Peroxid of Hydrogen.—This is likewise an oxidizant, liberating free O (ordinarily about 10 volumes) in the presence of all kinds of organic matter. It seems to have a special affinity for pus, and may be used to detect the presence of a purulent secretion in a cavity, by the effervescence which ensues on injecting the fluid. The principal objection to the remedy is its instability and the consequent uncertainty of each specimen. Other disadvantages are its corrosive action upon metals and the danger of explosion of the confined fluid when heated.

Quinin. — The salts of quinin have a special destructive predilection for the *Plasmodium malariæ,* even in as weak solution as 1 to 20,000. The sulphate is generally antiseptic in the strength of 1 to 800; the hydrochlorate, 1 to 900.

Resorcin.—This benzene derivative has come into prominence as a gastrointestinal antiseptic and as an ingredient of soaps and ointments for parasitic and scaly skin diseases. Large doses, ½ dram or more, induce the symptoms of depression characteristic of phenol compounds.

Salicylic Acid.—According to Miquel, this product is antiseptic in the strength of 1 to 1000. Its unquestioned efficacy in rheumatism probably depends on its antiseptic properties. It is not a good dressing for wounds, since it irritates and macerates the tissues and does not stay in place. The internal administration of the acid made from phenol, particularly, may cause roaring in the ears, headache, delirium, and erythema; 48 grains, taken within four hours, have produced death in an adult.

Salol.—The salicylate of phenol is broken up by the pancreatic juice into carbolic and salicylic acids. It has been used extensively for infectious intestinal diseases and even for cholera, but Reiche states that in the Hamburg epidemic of 1892 salol was an utter failure.

Silver Nitrate. — This well-known compound has been rated by Behring next to $HgCl_2$ in antiseptic potency. It can be utilized in nearly all inflammatory and ulcerative states of the mucous membrane. Perhaps its most noteworthy application is in ophthalmia neonatorum. The use of $AgNO_3$ as an antiseptic is limited by the discoloration of the tissues which it produces, its neutralization by NaCl in the secretions, and the possible dangers of argyria. There are many excellent substitutes for $AgNO_3$.

Soap.—According to Parkes, ordinary soap possesses marked disinfectant properties. He adds that there is little or no advantage in using soaps impregnated with small quantities of disinfectants. A 2- to 4-per-cent. boiling solution of washing soda is likewise an effective detergent.

Sozoiodolic Acid.—This is a diiodophenolsulphonic acid, $C_6H_2S_2OH.SO_3H.3H_2O$. It is used in 2- or 3-per-cent. aqueous solution. The salts of this acid with Na, Zn, Pb, and Hg are called iodozols.

Sulphurous Acid.—The gas, SO_2, produced by the burning of S, unites with aqueous vapor to form the strongly germicidal

H_2SO_3. The dry gas is but freely destructive of germs; hence the necessity of placing the sulphur dish in a vessel of water or of spraying objects beforehand with an atomizer. The H_2SO_3 thus produced kills the bacillus of anthrax in 5-per-cent. solution or non-spore-bearers in 1-per-cent. solution within twenty-four hours; also flies, mosquitoes, bugs, and rats. For fumigation three pounds of S are required for each thousand cubic feet of space—4 per cent. of SO_2. The fumigation should last at least twelve hours, with doors and windows closed and the cracks well stuffed with cotton. SO_2 has the disadvantages of corroding metals and bleaching colored fabrics. Liquid SO_2 (— 18°) is sold in glass siphons or metallic holders for disinfectant and refrigerant purposes.

Tannic Acid.—In addition to its valuable astringent properties, Abbott has found that this drug is antiseptic in solutions of 1 to 400.

Thymol. — This stearopten has one-fourth the antiseptic potency of carbolic acid. It is used for respiratory affections in the form of sprays or inhalations, and externally in ointments for scaly skin diseases. Thymol has a pleasant odor, attractive to flies, unfortunately. It is specific against the hookworm.

Tricresol. — This colorless mixture of the three cresols (ortho, meta, para) is freely soluble in water, and is a much more effective germicide than phenol, while it is not so corrosive or poisonous. It is employed as a preservative of antitoxic sera. Saponified or as cresol salts, the cresols readily penetrate albuminous matter.

Turpentine. — The oil of turpentine and its derivatives, terebene and terpin hydrate, are of some power as antiseptic agents, but are too irritating for surgical ends, as a rule. Turpentine, in conjunction with tincture of iodin, is a very valuable application for ringworm.

Urotropin. — Hexamethylentetramin is a valuable urinary antiseptic, especially after typhoid fever. It liberates formaldehyd in the urinary passages only when the urine is acid. It is probably our best general internal antiseptic (B. coli infection, meningitis, cholangitis, purulent otitis media).

Vinegar.—Klein and McClintock agree that dilute acetic acid (7 per cent.) is as efficient in preventing the growth of micro-organisms as is a 1 to 1000 solution of $HgCl_2$. Kitasato found that a 3-per-cent. solution of the acid kills typhoid bacilli in five hours. Acids generally are inimical to germ-life.

Zinc Phenolsulphonate (Sulphocarbolate).—This is an excellent astringent antiseptic for internal use (dose, 2 grains) and for local application (3 grains per ounce) in skin diseases, sore throat and leucorrhea.

QUESTIONS ON SANITARY CHEMISTRY.

1. Explain darkening of permanganate solution in the presence of reducing agents.

2. How detect Na_2CO_3 in residue from evaporated milk?

3. What is formed when NH_3 combines with HCOH after disinfecting a sick-room?

4. Name five oxidizing disinfectants.

5. What are the final products of the oxidation of organic matter?

6. Name two reducing disinfectants.

7. Name three coagulating disinfectants.

8. Name an oxidizing and an absorbing deodorizer.

9. How remove acidity due to CO_2 from water?

10. How does pumping considerably from a farm well increase the amount of impurities in the water?

11. How does agitation with iron filings purify drinking-water?

12. Why is deep well water harder than rain water?

13. Why is soft water better than hard for boiling meat and vegetables?

14. Are plants in sleeping-rooms healthful or not?

15. To test the air of a certain room quantitatively for CO_2, if the flask is brought from without the room, how can you empty the air already in it and fill it with the air of the apartment to be tested?

16. What is the yellowish color produced by nesslerizing?

17. Why should all cellars be cemented?

18. With a blotting-paper and suitable reagents how could you prove the presence in the air of NH_3, H_2S, ozone, SO_2, or Cl?

19. Why is the presence of NH_4 compounds in deep water of less serious significance than in surface- or subsoil-waters?

20. How prove the presence of alum in a baking-powder?

21. Explain the corrosive effect of $HgCl_2$ on surgical instruments.

22. How much carbolic acid is needed to disinfect a pint of tuberculous sputum?

23. How often should the air be changed in a sleeping-room 12 x 14 x 8, occupied by man, wife, and child?

24. Describe the changes which organic matter undergoes in the soil.

25. Write equation for the reaction between oxalic acid and potassium permanganate.

26. What objection to throwing much chlorinated lime down drains?

27. The pharmacopeial limit of K_2CO_3 in KBr is 0.138 per cent. Directions are given to add to 1 gm. of the salt in 10 c.c. of water 0.02 c.c. of normal H_2SO_4, after which phenolphthalein should give no color unless the carbonate is in excess. Give reasons.

28. If a few drops of $(NH_4)_2S$, added to a tall cylinder of water, give a brown-black coloration not cleared by HCl or KCN, what poisonous metal is present?

29. How can one separate metallic Fe from tea, which it is sometimes used to adulterate?

30. If blotting-paper, soaked in vinegar and dried at a gentle heat, becomes blackened, what adulterant is probably present?

31. How do tannin compounds act as intestinal disinfectants?

32. Why does stagnant water become putrid?

33. If Na_2CO_3 added to a solution of table salt yields a white ppt., what impurity is present?

34. Why should $KMnO_4$ not be employed for disinfecting clothing?

35. Why are new-built houses persistently damp?

36. What does a sp. gr. above 0.917 indicate as regards the purity of olive-oil?

37. Explain the principle involved in sterilizing catgut by boiling with $(NH_4)_2SO_4$ solution.

38. Reason out a method of separating Li salts from other alkaline salts in natural waters.

39. How detect the presence and determine amount of water in lard?

40. Give a simple test for detecting presence of $CuSO_4$ in pickles or peas.

41. If the ends of a can of vegetables are swelled out, giving a hollow sound on striking, what does this signify?

42. Aristol has sometimes been substituted with a mixture of boric acid and acetanilid colored with Fe_2O_3. How could you detect each of these?

43. Mention the chief distinctions between "oleo" and true butter.

44. How detect the presence of glucose in honey?

45. Which spice contains normally considerable starch?

46. How determine the percentage of water in flour or bread?

47. Name two poisonous elements which may be present accidentally in food or drink.

48. Why do canned blueberries often have a "tinny" taste?

49. What substance is used to give stale meat a fresh appearance?

50. Why are the tests for formaldehyd less likely to react with sour than with sweet milk?

51. How detect the presence of paraffin in candies?

52. What very poisonous liquid has sometimes been used in galenic preparations in place of official alcohol?

TOXICOLOGY.

DEFINITION.

To DEFINE a poison is about as difficult as to explain the signification of a weed. All medicines of any strength whatever may produce toxic effects; in fact, with the ancient Greeks the same word was used to express both a poison and a medicine. One-half pound of common salt, taken for tapeworm (and 4 ounces of concentrated solution injected subdermically), has caused death by its paralyzing effect upon the nervous system. Perhaps the best definition of a poison, then, is any substance which acts injuriously within and upon the human body, and is capable of causing death in a way not merely mechanic. Thus an injury or boiling water or steam may prove fatal, but, being mechanic in nature, they should not be classed as poisons. According to Brouardel, 25 to 30 per cent. of all cases of sudden death are without any discoverable lesion.

The toxic power of elements (Loeb) is inversely proportional to their solution tensions: *i.e.,* the elements which most easily give up their electric charges are the most poisonous. The toxic action of any salt is inversely proportional to the sum of solution tensions of both its ions: *i.e.,* to the decomposition tension of the salt.

ACUTE POISONING.

Poisons may be introduced into the body by the mouth, lungs, rectum, vagina, skin, or by hypodermic or intravenous injection. Toxic agents that are most soluble and diffusible are most rapidly fatal, especially when inhaled or injected intravenously. Insoluble substances have no action on the system until they have been more or less dissolved by the digestive secretions. A few poisons (curare, snake-venom, and the virus of syphilis, glanders, and small-pox) are comparatively harmless when swallowed, though most deadly when introduced directly into the blood, as through a bite or wound. Sleep or a full stomach may delay the absorption of a poison, and consequently the toxic symptoms, for several hours. The circulating poison is gradually eliminated (As in fifteen to thirty days, Sb in four months, Pb in eight months or more), a part having been stored up in the tissues for a variable period. It is believed that toxic effects are due entirely to that portion of the poison present in the capillaries. Gaseous poisons appear to be eliminated almost instantly by the lungs, no matter how introduced. A poison may gain entrance into the human system through the body of an animal without the latter being affected by it. Thus, cows and goats feed on stramonium with impunity, yet their milk becomes poisonous to human beings. Rabbits are immune to belladonna, but their flesh, after eating this plant, is poisonous to man. Honey made from gelsemium has caused poisoning.

How shall we determine that a person has been poisoned, accidentally or feloniously? Usually by the sudden advent of suspicious symptoms shortly after taking food or drink (especially if several persons are similarly affected), if accidental or homicidal; if suicidal, traces of the poison itself, and not infrequently the container, are to be found. In most cases the individual affected has been in previous good health. Symptoms of poisoning may be masked by alcoholism or sickness. Organic renal disease, by retarding elimination, may increase toxic effects. The influence of personal idiosyncrasy (see table of "Untoward Effects of Drugs") to certain foods and drugs should always be considered in a case of suspected poisoning. Young children are more tolerant than adults of calomel and belladonna; less tolerant of opiates. Poisonous plants have frequently a lurid purple color, a narcotic odor and an acrid taste, and many of them have a milky juice.

The most common symptoms of acute poisoning are violent pain, vomiting, purging, convulsions, delirium, and drowsiness: one or a few or all of these. It must not be forgotten, however, that toxic symptoms are simulated by many diseased conditions. Thus, cholera, cholera morbus, perforative peritonitis, ileus, and hernia resemble acute As poisoning as to the pain, vomiting, and purging; hydrargyrism appears much like dysentery; strychnin poisoning closely simulates tetanus; and coma is the foremost symptom in apoplexy, alcoholism, and insolation, as well as in opium poisoning. Food poisoning may resemble poisoning by arsenic, opium, belladonna, etc.

Even the post-mortem appearances of disease may resemble those found after death from poisoning, and the poison may indeed have been introduced into the body after death, as by embalming processes or by injection into the stomach or the rectum. In the latter event some of the poison will pass by osmosis into the liver and other adjacent viscera. Sodium arsenate solutions are sometimes pumped through the nostrils into the stomach by embalmers, permeating the whole body in twelve days. Suffocation by inhalation of vomited matters is often the direct cause of death in alcoholism and CO poisoning.

Circumstantial evidence, such as finding poison in the food or drink, is of great importance, but is not absolutely conclusive. The ordinary chemic tests are generally sufficient for revealing the presence of a poison in a body, but one must bear in mind how closely certain ptomains resemble in reaction the vegetable alkaloids. A person may die from the action of a poison, and none be found in the stomach.

Haines recommends to wash each article of chemic apparatus just before using it, with dilute alcoholic KOH, then with warm dilute HCl, and finally with an abundance of warm water. Weigh and measure the organs and their contents. Comminute the tissues finely with scissors, chopping-knife or hashing-machine, or pulverize in a mortar, and divide into three parts: (1) for volatile and mineral poisons; (2) for organic poisons, and (3) as a reserve against accidents. A fourth part may be needed if the circumstances point to caustic alkalies or corrosive acids.

To separate inorganic substances for chemic analysis boil the finely minced stomach or other matters with HCl and crystals of $KClO_3$ until a straw-colored liquid results; treat this with $NaHSO_3$ till a distinct odor of SO_2 is noted; then pass H_2S through the concentrated liquid, throwing down most metals as sulphids, from which a bead is readily obtained by reduction. Such destructive methods cannot be used for isolating organic compounds. Dialysis is a ready means of separating crystalloid poisons from the colloids in the stomach or intestines. A wide dialyzer (6 to 8 inches by 2 or 3 high) should be employed for twenty-four hours, having the two liquids at the same level. If the amount of the poison is small, or if it has entered into firm proteid combinations, very little may pass into the outer fluid.

Microchemic methods are of special service in medico-legal cases. In case of doubt physiologic tests should be made upon living animals, with control tests with equivalent amounts of the substance suspected to be present. Distillation is indicated in the separation of HCN and other volatile compounds. Alkaloids are isolated by acidulating the suspected material, heating carefully over the water-bath, filtering, washing with boiling distilled water, evaporating the filtrate, rubbing up residue with distilled water, and again filtering until a fairly pure product is obtained; then neutralizing with $NaHCO_3$, taking up freed alkaloid with ether or chloroform and evaporating spontaneously, leaving the pure alkaloid ready for testing. If proteins are present, they should be pptd. by warming (40°) for several hours with alcohol, before neutralizing with $NaHCO_3$, Na_2CO_3 or NaOH.

Stas's method for separating morphin and strychnin from other substances is to render the matter alkaline with Na_2CO_3 and shake liquid with four volumes of ether or amylic alcohol (best for morphin); let fluids separate, remove ethereal or alcoholic solution, and allow to evaporate.

To separate vegetable alkaloids from putrefactive products, Vaughan uses a 10-per-cent. solution of tannic acid in glycerin, raising the temperature to 60°-70° for two hours. This method, he says, does not wholly solve the difficulty in isolating morphin from simulating putrefactive bodies.

The local effects of poisons include erosion of mucous membrane (mineral acids and caustic alkalies), irritation or inflammation (irritant poisons generally), and special sensations, such as the tingling of the tongue produced by aconite, the dry throat of belladonna, and the local anesthesia of cocain. The mouth is bleached in poisoning by carbolic acid, $HgCl_2$, $AgNO_3$, potash, or soda (mucosa swollen, translucent, brown, and soapy). The odor of the drug on the breath is perceptible in poisoning by HCN, laudanum, alcohol, phenol, creosote, chloroform, I, P, camphor, nitrobenzol, NH_3 and acetic acid. Certain poisons have an elective affinity for various organs, as strychnin for the spinal cord, prussic acid for the heart, and opium for the brain. Very concentrated solutions of salts in contact with living cells withdraw fluids from the cells and ppt. their proteids, causing irritation, pain, nausea, vomiting, tremors, convulsions or paralysis.

The remote effects of poisons are either common, as fever, or specific. Thus, the pupils are dilated by belladonna, atropin, hyoscyamus, stramonium, aconite, alcohol, chloroform, conium, and opium (last stage). They are contracted by opiates, eserin, phenol, or chloral (during sleep). Coma is noted with opiates, alcohol, chloral, chloroform, carbolic acid, and camphor. The chief deliriants are the nightshade family, cannabis Indica, alcohol, and camphor. Convulsions are common symptoms with nearly every kind of poison, being probably due to reflex action, in the same way as teething or worms may excite them. Tetanic spasms are observed with nux vomica or strychnin, and less often from brucin, Sb, As, or even intense pain. Paralysis may occur in poisoning by eserin, conium (from below upward), aconite, and in chronic metallic poisoning. The mouth and tongue are dry in belladonna, hyoscyamus, stramonium, and opium poisoning. Salivation may be due to Hg, As, NH_3, pilocarpin, muscarin, cantharis, and corrosives generally. The skin is dry in poisoning by any of the nightshade family. It is moist in poisoning by opium and depressants generally (aconite, alcohol, tobacco, lobelia, Sb, etc.). A scarlet rash is noted in belladonna or stramonium poisoning and in ptomain poisoning from decayed meat or fish; urticaria in opium, chloral, cubebs, and salicylic acid; eczema from As; acne from tar or KBr; pustular eruptions from Sb or croton-oil; petechias from KI.

The blood is turned carmine by CO, H_3As, and KCN; dark-red by CO_2 and acid gases (tarry); dark by HCN; brick-red (in contact) by carbolic acid; black in contact with HNO_3 and other corrosives; chocolate-brown, with destruction of red cells, by reducing agents; dark and free from clots in alcohol and narcotic poisoning and all conditions causing death by asphyxia (nitrobenzol, strychnin, belladonna, most glucosids, H_2S, $KClO_3$, $K_2Cr_2O_7$) or syncope (aconite, digitalis); fatty and non-coagulable in P poisoning.

Concerning the effects of poisons upon gaseous exchange (Kravkoff), there is a marked increase, particularly of O (raising temperature), with strychnin and atropin; a lessened O-consumption with morphin and its derivatives, cyanids and pilocarpin. Digitalis increases the amount of O consumed by the tissues, but not the CO_2 eliminated.

The medico-legal duties of the practitioner in cases of supposed poisoning are: first, to preserve the life of the patient if possible; and, second, to forward justice by writing down his observations on the case as quickly as practicable. He should also take charge of any suspected food, medicine, vomit, urine, or feces, and seal them in new, clean vessels duly labeled for examination.

In the post-mortem examination (preferably within twenty-four hours) a double ligature should be passed around the esophagus in the chest, and another around the duodenum a few inches below the pylorus. The stomach is removed intact by cutting between each pair of ligatures, and is opened along the lesser curvature as soon as possible and its lining spread out and examined with a hand-lens for particles of poison. Another ligature should be tied low down in the rectum and the intestine removed to a separate clean vessel and scrutinized carefully. As much blood as possible should be secured for the chemist; also a part or the whole of the liver, brain, spinal cord, kidney, spleen, and thoracic viscera, and a large piece of muscle from the thigh or a portion of bone. In corrosive poisoning the mouth, esophagus, stomach, and duodenum should be removed together. Poisons are found in their greatest purity in the kidneys and urine. Hg is excreted largely in the saliva. The normal vivid congestion of the stomach after meals and the common post-mortem suffusions and autodigestion of the stomach ought not to be mistaken for toxic lesions. Perforation due to a corrosive differs from the small aperture of disease in being large and ragged, with soft, friable edges.

The dark color produced by caustic alkalies, HCl, H_2SO_4, and oxalic acid is due to imbibition of altered hematin. In $HgCl_2$, or phenol poisoning, the blood shows through as a bright brick-red. Mildly irritant poisons cause only cloudy swelling of the viscera. The post-mortem appearances produced by no poison are always the same.

The post-mortem examination should be as thorough as possible in order to discover if the sudden and fatal end were not due to some latent disease; for instance, to the perforation of an unrecognized gastric or typhoid ulcer. The mouth, lips, and tongue should be carefully examined for stains or erosions, and the skin for hypodermic punctures.

Decomposition of organs is best prevented by freezing, but pure alcohol may be utilized if necessary. The presence of As or Sb in appreciable quantities retards putrefaction for long periods, though mummification is no positive proof of arsenical poisoning. The jars should be sealed by attaching tape to both jar and cover by means of sealing-wax, the seal being retained, and a signed and dated label should be placed on each jar.

For practical purposes acute poisons may be divided into three main classes: corrosives, irritants, and neurotics. The first two affect principally the alimentary tract; the last, the nervous system. Corrosive poisons differ from irritants mainly in the intensity and rapidity of the symptoms, and a drug may be either irritant or corrosive according to the amount ingested or the degree of dilution. The cause of death from irritants is gastroenteritis, with or without specific remote effects. Corrosives cause death by acute laryngitis with edema, perforation of stomach, gastroenteritis, shock, or slow starvation.

Neurotic poisons have been subdivided into a number of varieties corresponding with the leading or selective action of the various drugs. Narcotics (opium, for example) act chiefly upon the brain, causing stupor and finally death from paralysis of the vital nerve-centers. Anesthetics produce fatal effects in the same manner, or indirectly by mechanic interference with respiration, as when a patient chokes to death from vomiting of bronchial mucus. The third stage of alcoholic inebriation, like that of anesthesia, is simply a narcosis, and should be treated in the same manner as the latter. The solanaceous deliriants act chiefly on the brain, producing delirium. Some neurotics (strychnin, for example) cause death by tetanic fixation of the muscles of respiration. The opposite condition of motor paralysis is noted with conium, curare, and Calabar bean. Others, like aconite and prussic acid, lead to death by syncope: that is, cardiac paralysis. A lethal result may follow overstimulation of the heart, leading to exhaustion, as in the case of digitalis.

Most irritant poisons belong to the mineral kingdom, whereas nearly all neurotics are of vegetable origin. Animal poisons taken by the mouth usually act as irritants; when received directly into the blood, as in dissection wounds, they play the part of depressing neurotics. Poisonous gases owe their injurious effects either to an irritant congesting action, as Cl and Br; to chemic decomposition of the blood, as CO and H_2S; or to a depressing influence upon the respiratory center, as CO_2.

The treatment of ordinary irritant poisoning consists, in general, of the following steps: 1. The administration of the chemic antidote, which means any safe and proper substance that will form, with the poison, an insoluble or innocuous compound. 2. The production or encouragement of emesis, or emptying the stomach with the siphon rubber tube or pump. Encourage vomiting with copious draughts of tepid water containing oil, lard or butter (dish-water). If the tube is employed, the stomach may be washed out with a solution of the antidote or with diluted milk or some other soothing liquid. A fountain syringe can be used very well in place of the stomach-tube. The best systemic emetic is apomorphin hydrochlorate, of which $1/15$ to $1/10$ grain (for an adult) may be injected hypodermically, and be repeated, if necessary, within twenty or thirty minutes; this drug will evidently be of no avail in deep narcosis, in which condition we use preferably the tube or pump. In the absence of the above-mentioned means of emesis, we may employ tepid or greasy water in quantity, or a dessertspoonful of ground mustard or common salt in a glass of warm water, or $ZnSO_4$, 20 to 30 grains (5 grains for children) in water, or for children a teaspoonful of syrup of ipecac; the simple operation of tickling the fauces is likewise not to be despised as a means to the end. 3. The administration of demulcent drinks to allay irritation and prevent, to some extent, the further injurious action of the poison. Mucilaginous (linseed, acacia, barley, starch paste, oatmeal-gruel) and albuminous (eggs and milk) preparations serve a useful purpose here. 4. Emptying the bowels of any poison that may be retained there, as well as of the antidotal compounds, which would gradually undergo solution and absorption. Castor-oil (a tablespoonful) and epsom salts (1 to 4 ounces) are most generally useful. Croton-oil, 1 to 5 minims on a bread pill, is quite efficient. Senna, gamboge, and other drastics are best in narcotic poisoning. 5. Allaying pain by hot external applications and morphin hypodermically. 6. Combating shock with the stimulants at hand and doing whatever else judgment and common sense would dictate. 7. Using diuretics, especially pure water copiously, to which small doses of potassium acetate may be added. Catheterize and stimulate kidneys with hot applications over them. Pilocarpin hypodermically may be used as a sudorific. A useful measure is hypodermoclysis (or enteroclysis or intravenous injection) with physiologic salt solution (heaping teaspoonful to quart) at 110° F.

In the treatment of corrosive poisoning we use preferably, if anything, the soft-rubber tube for emptying the stomach, on account of the danger of rupture of the weakened walls. Neurotic poisons require, in addition to antidotes and evacuation, the administration of their respective physiologic antagonists, as chloral and chloroform against strychnin; atropin and caffein against morphin; brandy against aconite, etc. It is well to be careful in this connection so as not to substitute one kind of neurotic poisoning for another, and, generally speaking, not more than the physiologic dose of the opposing drug should be exhibited.

In the treatment of acute poisoning time is a very important factor, and the measures employed should be as rapid and energetic as possible. It will frequently occur that some of the more eligible antidotes are not at hand, nor to be had in a very short time. While waiting for their arrival it is well to use at once such other remedial methods as knowledge and judgment will dictate. Like other derangements of the bodily functions, every case of poisoning must be treated on its peculiar indications, and no amount of information can take the place of intelligent presence of mind.

ANTIDOTES IN GENERAL.

Some antidotes (milk, fats, oils, powdered charcoal, white of eggs) act mechanically by coating the mucous membrane or enveloping the particles of poison.

Magnesia, 1 part to 25 of warm water (1½ to 2 ounces at short intervals), is the most efficient antidote against acids and acid salts, and is also valuable in poisoning by metallic salts, such as arsenic. Calcium hydrate and carbonate (milk of lime, chalk, egg- or oyster- shells) are also good antidotes for acids, especially oxalic, and oxalates. The carbonates and bicarbonates of Na and K may be used against most poisonous metallic salts, particularly those of zinc. They are also useful against $K_2Cr_2O_7$, forming the neutral chromate. Ferric hydroxid is the antidote *par excellence* (10 to 1) for arsenic. Soapsuds (1 to 4 of water) by the cupful is a most effective antidote against corrosive acids and salts. Copper carbonate, 3 to 6 grains with sugar and water, preceded and followed by an emetic, is recommended for P poisoning. Dilute H_2SO_4 is used as an antidote for soluble salts of Pb and Ba. Diluted NH_3 by inhalation is useful against vapors of corrosive acids, nitrobenzol, Cl, Br, and HCN. Sodium hyposulphite, 15 grains in very dilute solution frequently repeated, is a good antidote for bleaching powder and other hypochlorites.

Gum arabic in copious draughts is recommended against toxic symptoms from Bi salts. Starch paste (1 to 15) neutralizes I and Br. Oils and fats are efficient antidotes for caustic alkalies and metallic oxids. They should be avoided in poisoning by P, carbolic acid, cantharis, or Cu salts. Weak vegetable acids are of service against corrosive alkalies. Albumin is an ideal antidote for most metallic salts, and is effective against acids, alkalies, I, Br, Cl, creosote, anilin, and alcoholic solutions of alkaloids. It should be given well diluted (whites of 4 eggs to a quart of tepid water) and be followed by emetics and cathartics. Milk is a good substitute for egg-albumin, but is contraindicated if fats are.

Tannic acid (15 to 45 grains in a 2-per-cent. solution every quarter-hour) is an efficient chemic antidote for all alkaloidal salts and for tartar emetic. Its effect is enhanced by the addition of 10 per cent. of I. As a household remedy, it may be given in the form of a strong infusion or decoction of green tea. H_2O_2 is antidotal to cyanids, P, and alkaloids. $KMnO_4$, grain for grain of the poison and well diluted, is useful as an oxidizing agent against all organic compounds, when the poison is still in the stomach. Animal charcoal has also been used as an antidote for alkaloids, which it renders more or less inert by absorbing them. Iron filings are antidotal to Cu or Hg poisoning.

If the nature of the poison is quite unknown, a harmless and useful antidote is made with equal parts of magnesia, wood-charcoal, tannic acid, and ferric hydrate, given freely in plenty of water.

CORROSIVES.

The general symptoms of corrosive poisoning are severe and immediate burning pain in the mouth, throat, stomach, and abdomen (increased by pressure); staining and erosion of the mucous membrane of the mouth and throat; vomiting of stomach contents, mixed with mucus and blood, and often followed by bloody purging (constipation with mineral acids); great thirst; dysphagia, dyspnea, aphonia; headache and marked prostration—pulse small and weak, skin cool and sweating; convulsions common; painful cramps in calves (coagulation of myosin); urine scanty or suppressed; mind usually clear; peculiar drawn, haggard facies. The case may end in asphyxia, stupor or convulsions. Common sequels in case of recovery are nephritis and esophageal stricture. Copious dilution with water or milk is in order. Tracheotomy may be required for asphyxia, which a few drops sometimes excite when they enter the larynx.

MINERAL ACIDS.

These include nitric, hydrochloric, sulphuric, phosphoric, and chromic. All produce acid vomit and dry, gray-white eschars. The tissues are stained yellow by nitric; white or grayish, turning brownish, by hydrochloric; light-yellow, becoming gray-brown, by chromic; dark gray-brown and deep eschars by sulphuric acid (swollen tongue). The vomit is brown with nitric acid; dark-yellow with hydrochloric; dark with sulphuric, and yellow-red or green with chromic. Black woolen cloth is stained yellow by nitric acid (quickly burns a hole); bright-red or green by hydrochloric; wet-red by sulphuric. The H_2SO_4 stain soon becomes rotten. It is red at first, then dirty brown (yellow with logwood and madder; no change with indigo). Mineral acids in the blood ppt. proteins and decompose hemoglobin. Distressing eructations of gas occur with HNO_3.

The smallest fatal dose of mineral acids ranges from 1 dram H_2SO_4 and 3 drams HNO_3 to 4 drams HCl; less than ½ grain of CrO_3 has proved fatal. The usual period of death is from eighteen to twenty-four hours, though much sooner if the acid acts directly on the respiratory apparatus. The best antidotes for the mineral acids are mild alkaline drinks *ad libitum,* such as lime-water, soapsuds, and calcined magnesia suspended in milk. If these are not at hand, give lime from the walls, chalk, or baking-soda. Dilute the acid with plenty of water. Small pieces of ice may be given for too severe retching. Coma may be opposed by intravenous injections of Na_2CO_3. For external vitriol burns soda is a good antidote after wiping off the acid with a dry cloth.

VEGETABLE ACIDS.

These also produce acid vomit and dry, white eschars. Oxalic acid (sometimes mistaken for epsom salt) is characterized by a very sour taste; it may produce aphonia, tingling, muscular twitching, coma, collapse or tetanic convulsions. It causes an orange stain on black cloth. A dram has produced death within an hour (shortest fatal period 3 minutes). Crystals of CaC_2O_4 are found in the urinary tubules. Acetic acid is distinguished by the odor of vinegar. Grayish or blackish eschars may be seen in the mouth. Tartaric acid yields a burnt-sugar odor on heating. Lime-water is a good antidote for all three vegetable acids, particularly for oxalic. Other antidotes for the other acids are magnesia, soapsuds, chalk, baking-soda, wall-plaster, whiting, and tooth-powders. Other alkalies than lime-water should be avoided with oxalic acid, since alkaline oxalates are soluble. The oxalate ion has a specific toxicity to all protoplasm, probably by rendering Ca insoluble.

CAUSTIC ALKALIES.

This class includes alkaline hydrates and oxids and carbonates (lye, washing-soda, sal volatile). They produce brownish, ropy, alkaline, mucous, bloody, soapy, frothy vomit and wet, sloughing sores (raw, brown tongue and lips). They have a very acrid, burning taste. Edema glottidis is very liable to be caused by ammonia. Strong hydrates leave a brown stain on black cloth. The smallest fatal dose on record is 30 grains of potassa.

Death usually takes place within a few hours. Caustic alkalies are safely and readily neutralized by an abundance of any fixed oil (linseed, almond, olive, cottonseed) or fat (butter, lard), forming thereby a soap. Weak vegetable acids, such as lemon-juice or orange-juice and vinegar, fulfill similar indications, but less acceptably. Demulcent drinks should be given freely. Emetics and the stomach-pump are contraindicated.

CHLORIDS.

Corrosive sublimate may produce toxic symptoms as bed-bug poison, antiseptic tablets, or vaginal douches. It has a styptic, metallic taste, and coats the lips and tongue white. The vomit is glairy or bloody. There is constant purging with fluid, greenish (sometimes rice-water or dysenteric) stools, intense pain, and tenesmus. The urine may be suppressed. Fever is often present.

Cramps of the extremities are common. $HgCl_2$ corrodes and darkens metals. The smallest fatal dose on record is 3 grains; time, one-half to five days. White of egg is the best antidote, 1 for every 4 grains. The resulting albuminate should be removed quickly to prevent its solution in the digestive juices. Saline purgatives and large draughts of soothing liquids are also in order. Death is due to collapse, coma, or convulsions. An enormous number of lime infarcts in the necrosed kidneys is characteristic of mercurial poisoning; also dysenteroid erosions of the small intestines.

The butter of antimony causes grumous vomit, violent purging, and great depression. The chlorid of zinc, used in soldering and embalming fluids, has killed in the dose of 6 grains. Baking-soda in plenty of water, as well as eggs or milk, are indicated.

NITRATES.

Saltpeter causes frequent urination, tremors, convulsions, delirium, prostration, or collapse. Two drams of it has caused death.

Lunar caustic shows a glazed appearance of the mucous membrane, and the vomit darkens on exposure to light. Thirty grains has caused death. Common salt is the antidote.

PHENOLS.

Carbolic acid produces hard, white patches in the mouth which are easily stripped off, frothy vomit, contracted pupils, blackish-green urine, depressed temperature, speedy coma, and collapse. The breathing is slow and deep at first; shallow and hurried toward the end. The breath has the peculiar odor of the acid, which gives a violet color with $FeCl_3$. Twenty-two grains have proved fatal; the period of death ranges from one-half to twelve hours. There may be delirium, twitchings, convulsions, and high fever. In protracted cases bronchitis and bronchopneumonia may end the scene. Phenol has been absorbed through the intact skin (produces brownish shrunken patches). The continuous application as a compress of even a 1-per-cent. solution has caused gangrene. Sometimes severe eczema results. A dram in a quart of water, used as a uterine douche, proved fatal.

Alcoholics serve as the choice of antidotes, and further as needed stimulants. They form ethyl phenate, $C_2H_5C_6H_5O$, which does not turn violet with $FeCl_3$, as phenol does. Epsom or Glauber salts are also useful remedies. The stomach should be cleared out quickly with the tube or apomorphin. Oils and fats must be avoided. Milk and white of egg are useful. Glycerin prevents the caustic and toxic action of phenol, since the latter does not ionize in glycerin. The subcutaneous injection of ½ to 2 liters of sodium sulphate solution (2.3 per cent. dry salt, 4.6 per cent. crystals) has restored consciousness and prevented fatal consequences in phenol poisoning.

Other phenols which may produce poisonous effects are cresols, creosote, guaiacol, salol, and creolin. Naphthalene (coal-tar camphor) produces headache, vomiting, colicky pains, diarrhea, tenesmus, and burning pain in urethra, bladder, and kidney. The urine is dark-brown in color. Beta- and alpha-naphtol cause vomiting, coma, and nephritis (urine dark-brown). One dram applied externally has caused death. Pyrogallol has caused jaundice, cyanosis, chills, vomiting, diarrhea, strangury, and nephritis.

IRRITANTS.

The symptoms of irritant poisoning are similar to those of corrosives, but are generally less intense, and do not come on for some minutes or hours. Great thirst, severe headache, giddiness, cramps in the legs, torpor, coma, and convulsions are common symptoms. Dilute mineral acids and other corrosives may act as irritant poisons.

MINERAL.

Arsenic is present in white arsenic, fly-paper, fly-powder (cobalt arsenid), "Rough on Rats" (As_2O_3 and charcoal), "Tough on Mice," Scheele's green (candy, wall-paper), Paris green, cancer cures; colored crayons, and artificial flowers. Special symptoms of arsenical poisoning are the suffused and reddened eyes, brown vomit often mixed with bloody mucus, bloody or choleraic stools with tenesmus, subnormal temperature, and prominent nervous symptoms. The skin is cold and clammy. The urine is often partly suppressed. Pain is generally severe, but may be slight or absent; numbness and tingling are complained of. The symptoms usually begin in from fifteen to sixty minutes. The smallest fatal dose was 1½ grains; fatal period, twenty minutes to twenty-four hours; average, ten. Death may occur with epileptiform convulsions, collapse, and coma. If a number of hours elapse before death supervenes, the post mortem reveals gastroenteritis, and the intestinal contents contain bile and resemble rice-water. If the contents of the intestines show more than ⅒ mg. of arsenic, we may be sure that it did not come from normal food (Gautier).

After thoroughly emptying the stomach with the pump, tube, or emetic, one should neutralize the remaining poison that cannot be washed away. This is done by means of magnesia with freshly made magma of ferric hydrate (made by mixing equal parts of tincture of iron and ammonia-water, and straining and washing the precipitate), of which the dose is a tablespoonful every half-hour for four to six doses—at least twenty times the amount of poison. This forms insoluble $Fe_3(AsO_4)_2$.

Demonstration of Antidote for Arsenical Poisoning.—Render $FeCl_3$ solution alkaline with NH_4OH, throwing down ppt. of $Fe(HO)_3$ on a cloth; wash clear of NH_3, and then stir the ppt. into a beaker containing an arsenic solution. After five minutes filter and prove absence of As in filtrate.

Another good antidote for arsenic is dialyzed iron. Stimulants (brandy, aromatic spirit of ammonia, strychnin) should be given hypodermically for faintness, and, if the patient is cold, use hot blankets. After the sickness subsides an ounce or two of castor-oil should be given.

Antimony poisoning is characterized especially by excessive vomiting and depression; often subnormal temperature; also by a strong metallic taste, by early salivation, profuse sweats, and rice-water stools. The urine is usually increased, with painful micturition. Later it may be diminished or suppressed, and it often contains albumin. Two grains of tartar emetic have caused death. Tannin is the best antidote; ferric hydrate is next best; lime or magnesia is useful. Encourage vomiting with warm drinks, stimulate freely, and keep patient warm with hot blankets and bottles.

Acute lead poisoning is manifested by intense abdominal pain, with hard, retracted abdomen and constipation; the stools are black. If the case is protracted, local paralyses and the blue line on the gums appear. Any lead salt or solution turns black with H_2S; lead salts are also easily reduced to a bead. One ounce of sugar of lead has proved fatal. Any sulphate (preferably $MgSO_4$) will ppt. Pb solutions and act as an antidote. A hypodermic of morphin will usually be required for the pain.

Pure Bi salts, taken internally or used locally, may cause fever, stomatitis, loosened teeth with bluish-black discoloration of gums and tongue, gangrene of soft palate, vomiting, diarrhea, ulceration of intestines, dark urine, and albuminuria. Two drams of subnitrate (subcarbonate less poisonous) have caused death. These salts are eliminated largely by the saliva.

Copper poisoning (blue vitriol, verdigris) excites greenish vomit and a very marked metallic taste; ½ ounce of verdigris has caused death. In acid solution metallic copper is pptd. on a knife-blade. Milk and eggs are antidotes.

The chlorid of tin used in dyeing has sometimes given rise to toxic effects. It is more depressant than irritating, and causes diarrhea, cyanosis, and collapse. A fragment of Zn ppts. the metal in arborescent form. Milk and eggs are in order; magnesia is also an antidote. Tin in solder is dissolved by fruit acids, particularly cherries.

Both copperas and tincture of iron have caused death when taken in very large doses (1½ ounces of tincture). Iron solutions turn black with tannin or tea, and cause a dark-greenish fur on the tongue. Paralysis of extremities and suppression of urine may occur. Baking-soda or magnesia and milk and mucilaginous drinks are indicated.

Common alum in very large doses may produce toxic symptoms, especially vomiting. It has a sweetish, styptic taste, and there is sometimes frothing at the mouth. The chief antidotes are milk and baking-soda.

Zinc sulphate (sometimes mistaken for Epsom salt) in large doses causes excessive vomiting, dilated pupils, and coma. One-half ounce has proved fatal in about twelve hours. Vomiting should be encouraged by copious draughts of warm water. Antidotes are lime-water, albumin, soapsuds, and tannin.

Potassium dichromate has caused death in a number of instances, 2 drams being the smallest fatal dose. The vomit is yellow, the pupils dilated, and there is violent purging and muscular cramps. Ammonia-water gives a green ppt. Lime-water or magnesia and milk are good antidotes.

Barium salts cause convulsions, paralysis, cardiac palpitation, disturbed vision, very slow breathing, unconsciousness, collapse. One dram has proved fatal. Epsom or Glauber salts are purgative antidotes, and should be followed by emetics and by fixed oils to soothe. The flame-test is greenish. The symptoms of loco poisoning in horses and cattle are ascribed to Ba salts, the dried plant containing up to 1/12 of 1 per cent. of barium acetate.

The chlorate, sulphate, and bitartrate of potassium are all capable of exciting toxic symptoms; 1 dram of chlorate has caused death, and 1½ ounces of cream of tartar likewise. The chlorate is marked by rigid limbs, delirium, coma, and bloody urine. The bitartrate poisoning resembles that by niter. Sodium bicarbonate neutralizes the bitartrate. Opium, stimulants, and demulcents are called for.

Bleaching powder taken internally acts as an irritant poison. It has a sharp, acid taste and a distinct odor of chlorin. It is best counteracted by lime-water and oils.

Iodin solutions in large doses are marked by an acrid taste, tightness about the throat, pain, vomiting, and purging; yellow stains are noted on the mucous membrane. Starch or flour in warm water should be given till the blue color disappears from the vomit. White of eggs and milk should follow.

Iodin freely applied to a raw surface may cause headache, gastric symptoms, and even suppression of urine. Fatal results have followed taking 20 grains of I or one fluidram of the tincture. Large doses of KI excite headache, thirst, abdominal pain, salivation, sore nose and eyes, and a pustular eruption.

Phosphorus poisoning may occur from swallowing match-heads (each contains 3 to 5 mg. P), ratsbane (1 to 4 per cent. P with oil, flour, sugar and coloring matter), or phosphorated oil, or by inhalation of phosphine. Special symptoms are a garlicky odor and taste; gradually increasing pain, beginning over the region of the liver within an hour to several days; jaundice on second or third day; muscular twitchings; petechiæ; delirium, spasms, albuminuria, hematuria, or suppressed urine (contains leucin and tyrosin); paralysis, coma, and collapse. The vomit is greenish or coffee-ground in color, and both it and the stools are luminous in the dark, especially on heating with sulphuric acid. The breath may also be phosphorescent. One-fiftieth grain has caused the death of a child (1/8 grain in adult) in from one to four days. There is no direct antidote for phosphorus. Useful oxidizing agents are potassium permanganate (4 grains to each ounce of water, leaving about a pint in stomach—oxidizes P to H_3PO_4, and is itself changed to MnO_2) and diluted H_2O_2. To evacuate bowels in P poisoning, give old turpentine, 1/2 dram, with mucilage every half-hour till an action occurs, and repeat for several days. As an emetic, copper sulphate is commonly used: 3 grains well diluted every fifteen minutes till vomiting occurs; it may aggravate gastroenteritis. Albuminous and mucilaginous drinks and milk of magnesia should be given, but no oils or fats. Oxygen inhalations are recommended. Post-mortem examination shows fatty degeneration of the liver, kidneys, heart, and other muscles, and a garlicky odor pervades the stomach. There is a marked reduction in the alkalinity of the blood. P burns should be treated with a lotion of chlorinated soda or a paste of chlorinated lime.

Demonstration of Antidote.—Place a bit of P in $CuSO_4$ solution for a few minutes, and note, on removal, the coating of Cu phosphid on the piece of P.

Potassium permanganate in concentrated form may cause pain, shock, unconsciousness. Sulphurous acid, in dram doses frequently, is an effective antidote.

Petroleum compounds in excess produce burning pain, colic, vomiting, diarrhea, and painful urination (urine may have a violet odor); headache, vertigo, rapid pulse, dyspnea, fever, collapse, stupor, unconsciousness. The symptoms of benzin poisoning are cyanosis, dilated pupils, lowered pulse and respirations, clonic convulsions, and coma. One-half ounce of benzin has caused death. The treatment includes emetics, purgatives, stimulants; warm baths with cold affusions for collapse.

VEGETABLE.

Many resins (aloes, jalap, gamboge, scammony, bryony, elaterium) in too large doses cause excessive mucous purging, with intense griping pain and considerable depression. The stomach should be emptied and castor-oil given. Morphin hypodermically, mucilaginous drinks, emollient enemata, and hot fomentations are also useful. It is important to counteract great exhaustion. About a dram of gamboge or oleoresin filix mas, less than a dram of powdered colocynth, or 5 to 10 grains of podophyllin resin, have proved fatal.

Certain oils (savin, croton, castor, turpentine) may excite choleraic vomiting and purging, with contracted pupils, stertorous breathing, strangury, and collapse. One dram of oil of tansy (25 grains powdered drug), one ounce of oil of cedar, 15 m. croton-oil, or a tablespoonful of oil of pennyroyal, have caused death. The poisonous toxalbumin ricin is present in castor-beans, but not in the oil. Vapors of turpentine are somewhat poisonous. Internally this substance may cause convulsions and coma. A teaspoonful has led to the death of an infant. The white of eggs is the chief antidote. Epsom salts are useful against turpentine, for which hot fomentations to the loins are also serviceable. Brandy, aromatic ammonia, or other stimulant may be needed.

Colchicum preparations sometimes produce violent purging, with dilated pupils, cold skin, dyspnea, and rapid exhaustion. Tannin or strong tea or coffee ppts. the active principle, and stimulants are necessary. There is more colchicin in the seed than in the root of meadow saffron. The symptoms appear in from one to three hours (after oxidation to oxydicolchicin); $\frac{1}{3}$ grain is the smallest fatal dose, and death takes place in from twenty-four hours to several days. This poison acts on mucous membrane when injected hypodermically. A colchicin-like substance has been found in beer.

Black, green, and white hellebore or veratrum has a very acrid and bitter taste, and causes, in poisonous doses, slow pulse, violent vomiting, purging, and abdominal pain, with marked depression. It is treated like colchicum poisoning. Atropin, hypodermically, is useful. In fatal cases death does not take place usually till after twenty-four hours. The injection of veratrum alkaloids into a frog causes slow heart action, twitchings, and vomiting.

Ergot, or the fungus of rye, often taken to produce abortion, causes asphyxia, formication, dizziness, headache, mydriasis, dyspnea, delirium, coma, and heart-failure. It has a peculiar, nutty odor. Tannic acid is the antidote. Nitroglycerin is of service, and small doses of opium may be given after the stomach and bowels are emptied. The patient should be kept warm in the recumbent posture. The toxic constituents of ergot are cornutin (convulsant), sphacelotoxin (produces dry gangrene), and sphacelinic acid (spinal paralyzant). Ustilagism is due to a parasite on corn, and is marked by vasoconstriction and gangrene.

The symptoms of digitalis poisoning are chiefly a feeble, slow, intermittent pulse; nausea, grass-green vomiting, and purging; abdominal pain, vertigo, pale face, dilated pupils; severe headache, delirium, syncope; cold, clammy skin; chromopsia, cyanosis, convulsions, paralysis, coma. Death occurs from sudden heart-failure. Poisoning usually takes place from the cumulative effect of the drug given in repeated doses, rather than from a single large dose. The main point in treatment is to keep the patient in a horizontal posture. Brandy is useful, and aconite may be tried in very small doses and repeated if beneficial. Tannin, or strong tea, should be given to antidote the glucosids. Give atropin, caffein, and strychnin, and apply heat. Of the powdered leaves 36 grains, and of the tincture 1 ounce has caused death. A tendency to suppression of urine is a danger signal when administering digitalis medicinally. As a physiologic test inject 1 or 2 mg. of the suspected solution in a lymph-space of a frog, expose heart and count beats, which become slower and irregular, and may finally cease.

Lathyrus, or vetches (chick-peas), are marked by an initial chill, pain in the loins and legs, a girdle sensation, paresthesia, lameness, and gangrene. The adulteration of meals with chick-peas may give rise to lathyrism. Pellagra is thought to be due to saprophytes in fermenting corn.

All parts of the yew or laburnum-tree may cause toxic symptoms, such as vomiting, abdominal pain, narcosis, convulsive movements, and dilated pupils. They have a sweet taste. Cytisin warmed with nitric acid gives an orange-yellow color.

True hay fever (Dunbar) is due directly to a pollen-poison (from maize, ragweed. etc.) soluble in ether, blood-serum, and secretions and pptd. by alcohol.

ANIMAL.

Cantharis, or Spanish fly, used either internally or externally, may cause a dull pain in the loins, vesic tenesmus, strangury, priapism, salivation, and bloody vomit, stools, and urine. It blisters skin or mucous membrane. One should look for the shining gold-green wing-cases of the insects with a hand-lens. One ounce of the tincture (25 grains powdered drug; ⅓ grain cantharidin) has resulted fatally. Give plenty of water and a warm bath; empty the stomach, but do not give oils; wash out bladder with warm water. Charcoal, linseed-tea, mucilage, milk, morphin, and stimulants (by the rectum) are all of service.

Isolation of Cantharidin.—Extract by heating with 8 per cent. KOH to homogeneity; cool; separate from impurities with chloroform; acidulate with H_2SO_4; treat with four times the volume of alcohol; boil and filter hot; cool, refilter and distill off alcohol; take up cantharidin from residue with chloroform, and evaporate—residue blisters skin.

During putrefaction some ptomains appear (cholin, first; toxic mydalein, about the seventh day) and later disappear, to be succeeded by others, the toxic ones being most abundant from the fifth to the thirtieth day. Non-alkaloidal (insoluble in alcohol) products are more active than the alkaloidal. Protein foods not perceptibly tainted may be very toxic, while those decidedly putrid may be quite innocuous. Canned meats which splash on shaking are dangerous, from the contained gelatin-liquefying bacteria. Cooking meat or fish may kill the bacteria, but not destroy the toxins therein. Keeping protein food for a day or more, after cooking or after opening the container, is the most frequent cause of ptomain poisoning.

Ethylidenediamin (Kemp) is a ptomain produced in dilated stomachs. Methylguanidin, formed in the small intestine, causes nervous irritability and convulsions, which are also produced by muscarin, putrescin, and neurin (dyspnea, unconsciousness). Depression and shock in intestinal obstruction are due chiefly to pentamethylenediamin, H_2S, and methyl mercaptan, which are formed in the stagnating contents of the bowel (Kukula). Ptomatropin, found in decomposing fish, sausage, game, and canned beef, produces symptoms much like belladonna poisoning, and may react to Vitali's test. The production of indol depends largely on the activity of the colon bacillus, which ferments carbohydrates before acting on proteins. It causes (Kemp) headache, colic, diarrhea, neurasthenia, spasms, and cardiac and respiratory depression. Intestinal bacteria form phenol and cresol from tyrosin and break up lecithin into cholin.

Meat or sausage poisoning (botulismus, kreotoxismus, allantiasis) is due to anaërobic Bacillus botulinus or Proteus vulgaris, and occurs mostly in connection with raw or imperfectly cooked flesh, particularly of swine; the average incubation period is about eighteen hours. The symptoms resemble atropin poisoning. Putrid meat looks soft and smeary and has a grayish-green tint. The extract of 2.5 grams of putrefied meat is sufficient to kill a man (Bouchard). Meat poisoning may also occur from eating the flesh of pyemic or septicemic animals. The symptoms in this event are like dysentery, typhoid, or cholera. The stools are greenish or brownish, and very offensive.

Ichthyotoxins are present in salt herring and codfish, and especially in canned fish. Mytilotoxismus, the most fatal form of food infection, is caused by eating crabs, prawns, lobsters, cockles, and mussels. Cooked clams and oysters may still be poisonous. Galactotoxins, or milk poisons, are saprophytes causing the summer diarrheas of artificially fed infants. Disease of the udders may cause pseudodiphtheria or tuberculosis. Toxicogenic germs, chiefly of the colon group, are present in nearly all cheese, the colors of which are due largely to fungi. Tyrotoxicon (diazobenzene butyrate) is a poison formed at times in acid cheese, ice-cream, frozen custards, and cream-puffs.

Test for Tyrotoxicon.—Tyrotoxicon when pure gives a green coloration with equal parts of sulphuric and phosphoric acids; orange or reddish-yellow as it occurs in whey. Whitelegge and Newman direct to neutralize with Na_2CO_3, exhaust with ether, evaporate this solution and dissolve residue in water. The aqueous solution strikes an orange, red or purple color when treated with a mixture of equal parts of phenol and H_2SO_4. The substance is unstable and present usually only in very small quantity.

All these food-poisons produce fever or subnormal temperature, dry mouth and throat, vomiting and purging (sometimes bloody), suppression of secretions, hoarseness or aphonia, dilated pupils, squint, ptosis, diplopia, and a tendency to collapse, the pulse being usually disproportionately rapid. Vertigo, dyspnea, delirium, and a scarlet rash are occasionally noted. The onset is from one-half hour to a week.

The chief indication in food poisoning is to clear out (preferably by washing) the stomach and bowels as quickly and thoroughly as possible. Stimulants are often required to preserve the patient while the poisons are being eliminated. Atropin is very useful in antagonizing the neurin, cholin, and muscarin of meat poisoning. Inhalations of oxygen are of special service when the blood is disorganized and dyspnea is prominent.

GASES.

The inhalation of any gas except O causes suffocation. The more common acid vapors are bromin, chlorin, hydrochloric acid, and nitrous and sulphurous fumes. They are irrespirable and excite coughing and suffocation, cyanosis, narcotism, and sometimes convulsions, conjunctival and pharyngeal congestion, trembling, weakness, and hemoptysis. The concentrated gas may produce an immediate fatal result by closure of the glottis and asphyxia. The peculiar odor and color of the fumes aid in the diagnosis. Weak ammonia by inhalation is the antidote. Fresh air and rest are most important. Alkaline salt injections may lessen the cyanosis. Congestion of the lungs should be relieved, if necessary, by counter-irritants. Inhalations of ether relieve the sense of constriction from nitric fumes. SO_2 reduces the blood, rendering it very dark, and in fatal cases acid in reaction.

Alkaline vapors, such as strong ammonia, produce the same symptoms as acid vapors, with perhaps more burning in the throat and with vomiting and giddiness. Vinegar inhalations are antidotal. Otherwise the treatment is the same as for acid gases. In ammonia poisoning there may be immediate coma, and death in a few minutes. A teaspoonful of stronger ammonia has proved fatal. Death has occurred from suffocation or syncope within four minutes after inhalation of the gas.

NEUROTICS.

The members of this class act principally on the nervous system, after absorption, the symptoms usually beginning in about a half-hour. The class is variously divided into several varieties, the simplest arrangement being into narcotics, depressants, and convulsants. In neurotic poisoning intravenous injection of large quantities of physiologic salt solution retards and diminishes the toxic symptoms by hindering absorption.

NARCOTICS.

These are characterized chiefly by stupor, delirium, and insensibility, the latter supervening in from five minutes to many hours. Convulsions may occur. The treatment in general for narcotic poisoning is to give as an antidote for all the alkaloids tannic acid or strong green tea, or potassium permanganate grain for grain of the poison (the stomach may be washed with a solution of permanganate, 2 to 4 grains to the pint, leaving about a pint in the stomach). Charcoal is also of some service as an antidote. The physiologic antagonists most indicated are caffein (or strong coffee by the rectum or mouth), atropin (1/120 grain every fifteen minutes for three doses in morphin or opium poisoning), ammonia, strychnin, brandy, and amyl nitrite for heart-failure; morphin (till pupils begin to contract) and pilocarpin (1/2 grain) for belladonna, atropin, or other solanaceous poisons; and faradism of the phrenic nerve in the neck. The stomach should be emptied with tube, pump, or emetics (mustard is very good). Slap the chest with towels wrung from cold water; apply cold to the head and warmth to the extremities. Keep the bladder empty to prevent resorption of the poison. Artificial respiration may be needed for a time. In opium poisoning the patient should be kept awake by walking him about. For alarming symptoms during anesthesia invert the patient, hold up the base of the tongue, clear the fauces, inject stimulants, use nitrite of amyl by inhalation, and employ artificial respiration. Atropin and caffein are the most generally useful stimulants.

Cocain is coming into use as an antidote for morphin. Von Neusser recommends O inhalations. It is important in morphin poisoning to keep up the respiration, by which means the morphin is probably largely oxidized into inert products. The first product of oxidation is oxydimorphin $(C_{17}H_{18}NO_3)_2$, or pseudomorphin. On further oxidation it yields various color-products related to the color-roots, morpholin $HN(CH_2)_4O$, and phenanthrene. Morphin is eliminated to a considerable degree by the mucous membrane of the stomach, hence we should continue washing out this organ and giving antidotes.

Opium poisoning may take place by way of morphin, codein, laudanum, paregoric, soothing and cough syrups, poppy-tea, Dover's powder, black drop, Godfrey's cordial, McMunn's elixir, etc. One grain of morphin by the mouth, 4 grains of opium and 2 drams of laudanum have each proved fatal. Hypodermically morphin has up to three times the strength and rapidity by the mouth (Kobert). The effects of morphin poisoning usually begin in from twenty to forty minutes. The usual fatal period is from three to twelve hours, the earliest having been forty-five minutes. The leading symptoms are vomiting, staggering, excitement, then coma; pin-point pupils (may be dilated toward fatal end); slow, full pulse, becoming weak and irregular; slow, stertorous breathing, becoming feeble and of the Cheyne-Stokes type. The face is congested, becoming paler; the skin is cold and clammy and may show urticaria or itching. Convulsions are common in children, and may be tetanic in nature. Children are particularly susceptible to opiates.

Belladonna or atropin poisoning exhibits symptoms which are almost entirely opposite, namely: dilated pupils (impaired vision) and rapid pulse and respiration. There is active delirium and hallucinations; sometimes high fever; hot, dry skin, throat, and fauces, and maybe strangury and suppressed urine. A drop of the patient's urine instilled into the eye of a dog or cat will dilate the pupil in a few minutes. Dilatation of the pupil in lower animals, says Vaughan, may be obtained by the application of extracts from putrid animal tissue. One-half grain of atropin has caused death, as has also a dram of belladonna extract or a few of the nightshade berries. Poisoning by hyoscyamus, stramonium, or solanum (potato-sprouts, and sun-baked growing potatoes, chiefly in skins) shows similar symptoms. Hyoscin is a muscular paralyzant. Stramonium excites cardiac irregularity and furious delirium.

Cannabis Indica preparations have never caused death, but often produce alarming symptoms, particularly dilated pupils and exaltation of the senses. Minutes seem hours, and there may be joyous delirium or double consciousness. In addition to brandy and strychnin, lemon-juice freely is advocated.

Muscarin is the active principle of poisonous mushrooms or toad-stools (also contain neurin and helvellic acid, $C_{12}H_{20}O_7$; enzymes and toxalbumins, particularly phallin). These, when swallowed, produce gastroenteritis (tetanic spasms), vertigo, dim vision, marked myosis (mydriasis from amanita), intense dyspnea; feeble, rapid pulse; marked delirium; tremors, epileptiform attacks; lethargy, and coma. Pieces of the fungi may be found in the vomit. Death may occur in from two to one hundred hours. Emetics and warm water to aid vomiting, castor-oil and enemata, tannin, atropin, and coffee will do the most good.

Alcoholic coma is manifested by gradual stupor; snoring breathing; fixed, dilated pupils, and a ghastly, suffused, or bloated face with livid lips. The temperature is rendered subnormal by excessive heat radiation from dilated capillaries. There is an alcoholic or ethereal odor of the breath. Two and one-half ounces have proved fatal in from a few minutes to ten hours. Ammonium carbonate, strychnin, aromatic ammonia, capsicum, and coffee are of special value. Emetics, warm baths, lavage, rubbing, and hot applications are in order. Warm baths followed by cold affusions should be used for deep coma. The inhalation of kerosene fumes causes symptoms similar to those produced by alcohol.

Isolation of Alcohol.—Separate volatile substances by distilling with steam (from a separate vessel); acidulate faintly, if need be, with tartaric acid; redistill alcoholic distillate slowly over water-bath with MgO or K_2CO_3.

Wood alcohol is very dangerous, causing weakness, nausea, vomiting, blindness (vasoconstriction, degeneration), dilated pupils, and narcosis, which may last for days. In the body wood alcohol is only partly oxidized into formic acid, and is slowly excreted, hence cumulative. It has sometimes been used in Jamaica ginger, cologne, and essence of peppermint, as well as in bay rum and other toilet articles. Painters and varnishers are occasionally poisoned by inhaling the vapors. Less than a half-pint has caused death, usually not for a day or two. Wash out the stomach, give caffein and strophanthus, use warm baths followed by cold affusions, oxygen inhalations, bleed (a pint), and use at least 1500 c.c. of physiologic salt solution by hypodermoclysis. Sodium bisulphate has been suggested as an antidote, since it increases the elimination of formic acid.

Chloral poisoning ("knockout drops") is manifested by complete muscular relaxation; slow, feeble, irregular pulse and breathing (sometimes stertorous); subnormal temperature; pale or livid face; abolished reflexes, and an odor like bananas or pears. Chloral heated with caustic alkali yields the odor of chloroform. Death has been caused by 7½ grains of the hydrate in from a few minutes to a day (usually six to ten hours). Aromatic ammonia, atropin, strychnin, coffee, brandy, amyl nitrite, and O inhalations are useful agents. Mustard plasters may be used over the heart and the calves of the legs. Artificial respiration should be kept up for hours, if necessary. The patient must be kept warm.

Isolation of Chloral.—Acidify at once with tartaric acid, and distill with steam. To estimate in aqueous solution, shake with MgO (to remove free acids), and treat with excess of normal NaOH. Determine excess of alkali with standardized acid, and calculate chloral hydrate from difference: 1 c.c. alkali = 0.1655 gm. chloral hydrate. To separate chloral hydrate (glycuronate) from the urine, acidify with H_2SO_4 and shake with ether in a separatory funnel; chloral is left as a solid residue after evaporation.

Death by chloroform inhalations is due apparently to vasomotor paralysis. Sudden marked dilatation of the pupils, not reacting to light, is a danger-signal of importance. The breathing becomes shallow and the pulse feeble and frequent. As little as 15 minims inhaled has caused sudden death in persons with weak heart. By the mouth a dram has caused death in a boy of four years. Atropin is of special service in stimulating the sympathetic. Sodium bicarbonate is the antidote for poisoning by the mouth. The toxic effects of chloroform, taken internally, are subnormal temperature, nephritis, fatty degeneration, and sometimes death in a few days.

Isolation of Chloroform.—Post mortem, chloroform is detected in the lungs and blood by heating these in a flask connected with a hard glass tube, which is heated to redness. The chloroform is thus decomposed into perchlorbenzene, C_6Cl_6 (forms needle-like crystals in front of the flame), Cl (acts on KI and starch paper in tube below condenser) and HCl (ppts. AgCl from $AgNO_3$ solution in Liebig's bulb connected with aspirator).

Death under ether is generally from asphyxia, indicated by shallow breathing, rapid pulse, and cyanosis. The pupils are usually dilated. An ounce has caused death. The most important indications are to clear the throat of mucus and employ artificial respiration. Ether may cause death after anesthesia, by pulmonary congestion.

Large doses of camphor may excite toxic symptoms, such as burning pain in throat and stomach; foaming at the mouth; cold, clammy skin; retained urine; disturbed vision; tinnitus; paresis; delirium; convulsions, and coma. Three drams have caused death. Stimulants, warmth to the extremities, and hot and cold douches are specially indicated.

A large proportion of CO_2 in the respired air causes giddiness, ringing in the ears, irritation of the throat, loss of muscular power, feeble pulse and breathing, and coma. The pure gas terminates life instantly by apnea (asphyxia) from spasm of the glottis. CO_2 is classified as a negative narcotic, suffocative poison. The main point in the management of these cases is removal of the patient into the fresh air and the use of artificial respiration if the symptoms demand.

Carbon monoxid (coal-gas, water-gas) is a deadly narcotic poison, driving out oxygen and combining with the hemoglobin of the blood, which in extreme cases becomes of a markedly bright-red appearance. Small quantities of the gas produce headache, vertigo, muscular weakness, and nausea. A fatal termination is preceded by asphyxia, local paralyses, fever, or subnormal temperature, convulsions, and unconsciousness, with loud snoring—may be mistaken for drunkenness. The greater the leucocytosis produced, the graver is the condition. Death may usually be referred to cerebral congestion or hemorrhage. The treatment is not often successful, and includes removal into the fresh air and slapping the chest with wet towels, or resort to artificial respiration. Inject a pint or a quart of physiologic salt solution every hour as required. H_2O_2 in large doses by the mouth or rectum is recommended. CO is the active agent in the so-called charcoal poisoning practised by suicides in France. One per cent. in the atmosphere is dangerous. There is often frothing at the mouth, with purple lips and bleeding from the nose or lungs, in poisoning by the fumes of coal, coke, or charcoal. CO is the gas which in burning buildings suffocates persons before the fire reaches them.

Test for CO in Air or Illuminating Gas.—CO is absorbed by solution of CuCl in excess of HCl or NH_4OH. On heating to boiling the gas is expelled and burns with a pale blue flame. On dropping the gaseous solution into a bright-red solution of $PdCl_2$, a black ppt. of metallic Pd results—this test reacts also with H_2S, H, ozone and $(NH_4)_2S$.

Sewer-gas is a narcotic poison, and more than 1 per cent. in the atmosphere may prove fatal. The symptoms are nausea, vomiting, pains in the abdomen and extremities, vertigo, paresis, convulsions, and insensibility. The best treatment is removal into fresh air and the use of stimulants as needed. Apomorphin has been recommended as an antidote.

Formaldehyd, when freely inhaled or swallowed, produces vertigo, diarrhea, suppressed urine, burning in throat, vomiting, unsteady gait, cardiac depression, and sometimes coma, with stertorous breathing. For poisoning by inhalation, ammonia cautiously inhaled is recommended. When formalin has been swallowed, the treatment is the same as for acute alcoholic poisoning. Aromatic spirit of ammonia is a reliable antidote.

Isolation of Formaldehyd.—Make material into a paste with water that has been acidified with H_2SO_4; add excess of dry Na_2SO_4 and distill. All the HCOH passes over in the first portions.

DEPRESSANTS.

Depressants, or hyposthenia nts, are marked especially by feeble pulse and breathing, and cause death by paralysis of the heart or respiratory center. Insensibility does not come on until CO_2 narcosis supervenes. All depressants except the cyanogen compounds have as antidotes tannic acid or strong green tea. Hypodermics of strychnin, brandy, aromatic ammonia, ether, digitalin, and atropin, and the administration of strong coffee and amyl-nitrite inhalations are in order. The recumbent posture should be strictly maintained. Artificial respiration may be required. Mustard poultices to the pericardium do good. The patient should be kept warm (hot drinks, hot applications, and friction). Faradization or galvanization of the respiratory muscles is recommended by some authorities.

Hydrocyanic acid and substances containing it (cyanids, cherry-laurel, crude oil of bitter almonds, wild-cherry bark, cassava, pits of stone-fruit, etc.) produce almost immediate salivation; constricted throat; giddiness; falling; insensibility; convulsions (like epilepsy—often trismus and clenching of hands; pupils dilated and insensitive to light); glassy, protruded eyes; sobbing or stertorous breathing; frothing at the mouth; coldness, and collapse. KCN has a corrosive action. The acid itself usually kills in fifteen to thirty minutes. In protracted cases a severe bronchitis or pneumonia may develop. Death has followed the ingestion of 30 minims of the official acid, 2½ grains of KCN, and 20 minims of oil of bitter almond. The peach-blossom odor of HCN and cyanids is very characteristic. A watch-glass with a drop of $AgNO_3$ solution adhering to it, when held before the mouth of the patient, may show a white film of AgCN. Whatever is to be done must be done quickly. Empty the stomach immediately; slap the chest with a wet towel; use artificial respiration; inject atropin, strychnin, or ether, and use amyl nitrite or ammonia by inhalation. Chlorin-water and chlorinated lime are mentioned as antidotes. For the cyanids, which are somewhat slower in action, $Co(NO_3)_2$, or a mixture of ferric and ferrous sulphates with sodium carbonate might be of service. HCN acts in every way like asphyxia, interfering with assimilation of O. Dependent parts and the finger-nails often show bright-red or violet patches.

Isolation of HCN.—In cases of suspected poisoning by HCN or cyanids, the material to be examined should be distilled (with water if need be) and collected for testing. H_2SO_4 added to the distillate liberates HCN from the poisonous cyanids as well as from the non-poisonous ferrocyanids and ferricyanids. The presence or absence of the latter salts, therefore, should be determined before adding the mineral acid.

Nitrobenzene (oil, or essence, of mirbane) is like prussic acid in action, but much slower. It is marked by cyanosis, headache, drowsiness, ataxia, arhythmia, paresis, methemoglobinuria, Cheyne-Stokes breathing, and apoplectiform coma. The drug smells like oil of bitter almonds, but does not turn crimson with sulphuric acid. Fifteen grains have been fatal in from four to twenty-four hours. The treatment is the same as for HCN poisoning.

Benzene by the mouth or lungs causes tremors, headache, vertigo, delirium, convulsions, and coma. One ounce has been fatal.

Nitroglycerin is sometimes added to liquors ("knockout drops") for stealing or for homicidal purposes. It produces severe headache, weakness, vertigo, dyspnea, cyanosis, delirium, and coma. Coffee is of service in relieving these symptoms.

The nicotin of tobacco produces nausea, vomiting, purging, pallor, giddiness, slow pulse, great depression, tremors, cold sweats, contracted pupils, and tetanic or clonic convulsions.

There is a strong tobacco-odor about the patient; nicotin itself is colored blood-red or brown by chlorin. One minim of nicotin has proved fatal, the period of death being from five minutes to an hour or more. Only 1/2 dram of tobacco, given by enema, has caused death. The pieces of leaves should be examined under the microscope for their peculiar hairs.

Lobelia and its preparations give rise to symptoms very similar to those produced by tobacco, but there is more narcotism. The peculiar heavy, unpleasant odor of the plant may be noted. One dram of the leaves has led to a fatal result.

The fresh leaves of conium (hemlock) have been mistaken for parsley. It causes gastric irritation; vertigo; diplopia; ptosis; slow, labored breathing; dilated pupils; drowsiness; staggering; motor paralysis; dysphagia; aphonia, and asphyxia, and death from failure of respiration. It has a peculiar odor. The fatal dose of coniin is 1 minim; period, one to three hours.

Cocain poisoning is accompanied by a small, rapid, intermittent pulse; slow, shallow breathing; a sense of tightness about the chest; protruding eyeballs; dilated pupils; cold, clammy skin; excitement, fullness, and pain in head; hallucinations; delirium; convulsions, and coma. The patient may complain of feeling small foreign bodies under the skin and of dryness and burning in mouth, throat, and stomach. The drug makes the tongue tingle, then anesthetic. A solution dilates the pupil of a cat or dog when locally applied. Less than a grain (1/3 grain hypodermically) of the hydrochlorate has caused death in a few minutes to several hours.

Gelsemium preparations produce vertigo; diplopia; ptosis; dysarthria; dilated pupils; labored breathing; rapid, feeble heart; extreme weakness; wide anesthesia, and perhaps tetanic convulsions. A dram of the fluid extract has caused death in from one to eight hours. Morphin is specially indicated.

Aconite preparations find frequent use in medicines as fever-cures and neuralgia liniments; the root has been mistaken for horse-radish. Toxic symptoms (rarely delayed beyond an hour) are burning and tingling of tongue and throat; numbness of finger-tips and convulsive twitchings, leading to paralysis; cardialgia; weak, slow pulse; nausea, vomiting, and diarrhea; clammy coldness, dilated pupils; vertigo; slow, difficult, feeble breathing; clonic spasms, and very great prostration. Consciousness is retained to the last. Of the tincture, 25 minims have proved fatal; of the alkaloid, 1/20 grain. Death is sudden from collapse or asphyxia within three or four hours generally. Atropin, brandy, coffee, strychnin, and digitalis are most helpful. The back and limbs may be rubbed with hot towels.

Tests for Aconite.—Physiologic tests are most important, using graphic curves in connection with the injection of a standard solution of the same poison, for quantitative purposes. The pigeon, says Magill, is perhaps the most delicate means of studying the action and determining the amount of the poison. The poison is best proved (Sollmann) by its characteristic action (quickening, slowing, quickening, slowing) upon the frog's heart.

Laurel contains andromedotoxin, $C_{31}H_{51}O_{10}$. Its action is similar to aconitin, with pain in head and temporary blindness. It is sometimes present in honey. Locust bark, leaves, and root are poisonous, causing vomiting, dry mouth and throat, flushed face, dilated pupils, feeble heart action, and stupor.

Calabar bean, or physostigma, and its alkaloid are distinguished by the marked myosis they produce. Other symptoms are vertigo; nausea, vomiting; slow, shallow respiration; abolished reflexes, and general paralysis. Eserin gives a marked red color with bromin-water. Of this alkaloid, 1⅕ grains (six beans) have proved fatal. Atropin is the physiologic antagonist. Chloral is of use at an early stage.

The arrow-poison, curare or woorara, produces a chill; rapid, weak pulse; sighing, labored breathing; fever; protruding eyeballs; inco-ordination, and motor paralysis. Injected beneath the skin of a frog, it causes paralysis of the voluntary and respiratory muscles. A few grains have caused death in one and one-half hours or more. Alkaline solution of potassium permanganate is of service locally.

The coal-tar antipyretics frequently lead to cyanosis; slow breathing; feeble, irregular pulse; vomiting; profuse sweating, and profound prostration; jaundice, nephritis, jactitation, unconsciousness. Methemoglobinuria is often present, and the blood shows numerous nucleated red cells and marked leucocytosis. Headache powders may excite salivation and a discharge from the nose and eyes. Five grains of acetanilid have caused death. Alcohol, ether, strychnin, and oxygen inhalations are the best stimulants in such cases. Warmth should be applied to the feet and the body. Warm baths and cold affusions are useful.

Anilin oil causes marked gray-blue cyanosis (methemoglobin), headache, vertigo, feeble pulse, staggering, convulsions, and coma. A little less than an ounce has proved fatal.

Anilin dyes in clothing may excite local edema, eczema, or anesthesia. Anilin-black (used to dye boots) contains 90 per cent. anilin oil.

Antipyrin in toxic doses excites skin eruptions and edema of the face.

Bromoform poisoning (a few drops) is marked by cyanosis; pin-point (or dilated) pupils; shallow, irregular, stertorous breathing; weak, arhythmic pulse, and relaxed muscles. One dram has caused the death of a child. Thirty grains of iodoform have proved fatal; KBr is a physiological antagonist. Strychnin, hypodermically, is likewise recommended.

Santonin, used so extensively as a vermifuge, has caused death in the dose of 2 grains. The symptoms of poisoning are violet or green-yellow vision, trismus, dilated pupils, hallucinations, convulsions, and collapse. The urine is colored greenish-yellow; red, if alkaline.

The symptoms of trembles, or milk sickness, are ascribed to aluminum phosphate (an acidosis), present in certain plants, particularly white snakeroot and rayless goldenrod. Sodium bicarbonate is a preventive and antidote.

UNTOWARD EFFECTS OF DRUGS.*

DRUGS	ERYTHEMA	PAPULES	WHEALS	VESICLES	BULLÆ	PUSTULES	PURPURA	MISCELLANEOUS SYMPTOMS
Antipyrin	×	×	×	×	×		×	Pigmentation
Arsenic	×	×	×	×	×	×	×	Gastroenteritis, sore eyes, coryza, brown pigment
Boric acid	×							Fever, delirium, cyanosis
Bromids	×	×	×			**X**		Blunted senses, salivation, rupia-like eruption
Cantharides	×	×						Gastroenteritis, dysuria, chordee
Chloral	×		×	×	×		×	Fever, conjunctivitis, dyspnea, arhythmia, depression
Chrysarobin	×	×	×			×	×	
Coal-tar products	×	×		×				Tinnitus, depression, dyspnea, cyanosis, pigment
Cod-liver oil				×				Nausea, vertigo
Copaiba	×	×	×				×	Fever, headache, vertigo, stupor, dysuria
Creosote			×					White tongue, burning in throat
Cubeb	×	×						Gastroenteritis
Digitalis	×	×						Subnormal temp., headache, nausea, faintness, weak pulse
Ergot	×	×						Urticaria, gastralgia, amblyopia, icterus
Horse serum (antitoxin)	×		×				×	Slight fever, pain in joints, dyspnea
Iodids	×	×	×		×	**X**	×	Salivation, coryza, bronchitis, gastralgia, albuminuria
Iodoform	×	×	×	×	×		×	Fever, delirium, prostration
Mercury	×	×	×	×	×		×	Fever, salivation, vertigo, tremor, weak pulse
Morphin	×		×	×	×			Nausea, headache, itching, sweating, gastralgia
Pilocarpin								Salivation, nausea, headache, dim vision, pulmonary edema
Quinin	×	×	×	×	×	×	×	Fever, headache, deafness, blindness, pallor, coldness
Salicylates	×		×	×	×		×	Gastritis, headache, tinnitus, sweating, albuminuria
Solanaceæ	**X**	×	×	×			×	Fever, dry throat, dim vision, vertigo, delirium, tachycardia
Strychnin	×							Red eyes, gastralgia, nervous tension, twitchings, wakefulness
Tar		×						Gastroenteritis, vertigo, headache
Tartar emetic	×					×		Gastroenteritis, depression, cyanosis, nephritis
Turpentine	×			×	×			Diarrhea, dysuria, strangury, vertigo, headache

*The cross indicates the presence of the cutaneous sign. Multiformity of lesions is suggestive of a drug eruption.

CONVULSANTS.

These are characterized chiefly by tonic and clonic spasms. The mind is usually clear till near the end, due to paralysis of the vasomotor center. Nux vomica and ignatia contain the alkaloids strychnin and brucin. The former is sometimes used in vermin-killers. It has a very bitter taste, and produces restlessness, shivering, shuddering, epigastric pain, twitching muscles, sudden jerkings of the limbs and head, and especially tonic spasms of the neck, back, chest and diaphragm, followed by sweating. The resulting dyspnea is marked by a livid, congested face, which wears an unmeaning smile (*risus sardonicus*) and often foaming; the eyes are staring, pupils dilated, intense thirst may be complained of, and the pulse becomes very rapid and feeble. The senses are extremely acute, and the slightest noise or excitement may precipitate a spasm. Although there is a strange feeling in the jaw, this is seldom involved in spasm, and then late (distinction from tetanus). The symptoms of brucin poisoning are similar, but slower and less marked. One-fourth grain of strychnin, 30 grains (or one seed) of powdered nux, and 3 grains of brucin have resulted fatally. The period of death from strychnin is from five minutes to six hours; average, two hours. Tannic acid or hot, strong coffee or green tea and charcoal are useful antidotes. Keep the patient quiet in a darkened room; use chloroform or ether inhalations during the paroxysms; also artificial respiration if needed. Chloral in milk by the rectum is a most efficient antagonist; atropin is likewise useful. Ice to the spine is of some service. O inhalations are indicated if respiration is much diminished by spasm. If life is maintained for five or six hours, recovery is probable. Strychnin is eliminated partly unchanged in the urine. Rigor mortis after death from strychnin is persistent. Tetanus is more gradual (several days) in onset, with fever and rigors between attacks. The neck and jaw muscles are first affected.

Physiologic Test for Strychnin.—The frog is peculiarly susceptible to strychnin ($\frac{1}{18000}$ grain causes convulsions), and so furnishes a delicate test-subject for this alkaloid, the suspected matter being injected into the lymph-pouch under the skin of the back at the root of the legs.

Picrotoxin (1 per cent. of cocculus Indicus) sets up intense thirst, abdominal pain, choreic spasms (mostly flexor), giddiness, lethargy, delirium, coma, dilated pupils; labored, rapid, and then slow breathing; paralysis. It has an intensely bitter taste. Sulphuric acid gives with it an orange-yellow color. Three grains of picrotoxin have caused death in about a half-hour. The treatment is the same as for strychnin. Fishberries (grains of paradise, levant nuts) have been mistaken for cubebs, pepper, or wild cherries; 36 grains have caused death. Cocculus Indicus resembles the extract of hazelnut kernel, sometimes employed to improve the flavor of whisky, and has been used in "knockout drops."

Cicuta maculata (spotted-, wild-, or water-hemlock) is sometimes mistaken for parsnips or horse-radish. A piece of the root the size of a marble has proved dangerous to man. The symptoms and treatment are similar to picrotoxin. Oil of cedar may excite epileptiform convulsions and coma.

CHRONIC POISONING.

Chronic poisoning is generally the result of occupation or environment. The continued absorption of metallic substances leads first to neuritis and later paralysis. The treatment in general is to remove the cause if possible; to get rid of the accumulated poison by the administration of full doses of potassium iodid in plenty of water, and the symptomatic relief of paralysis and other symptoms by electricity and other suitable measures as indicated in the individual case. In the treatment of lead poisoning dilute sulphuric acid and magnesium sulphate are administered to ppt. the poison excreted by the intestine and eliminate it in this way. Injections of morphin and atropin may be occasionally required to relieve pain. The victims of drug habits, particularly morphinomaniacs, acquire a certain immunity to the poison taken, and often bear enormous doses.

LEAD.

Chronic lead poisoning is seen most frequently in painters, printers, plumbers, smelters, and founders; less frequently in potters, file-cutters, leather-cutters, pewterers, lace-makers, artists, tinners, glazers, glass-grinders, japanners, lapidaries and manufacturers of lead paints, glass enamel, hair-brushes, oilcloths, rubber, shot, sheet-lead, false pearls, (Pb_2SiO_4), etc. It may arise from drinking-water, especially when this is soft or carbonated; also from drinking acid liquors from pewter vessels or stopcocks. Other occasional sources are tin-foil goods, chrome-yellow in cakes and candies; acid canned goods (acting on solder) ; vinegar and preserves kept in glazed earthen vessels; snuff colored with minium or chromate; contamination of flour by plugs of lead in millstones; contamination during manufacture of acids and salts; leaden toys; colored paper; false teeth; biting off thread weighted with white lead; use of PbS or calcium plumbite as a hair-dye, or of carbonate as a cosmetic; abortifacient pills; the use of shot in cleaning bottles; soda or potash kept in flint-glass bottles; hat-linings glazed with white lead; lead plates in dentistry; collyria; vaginal injections; sleeping in freshly painted rooms. The enameled ware in common use is free from lead. Fresh lead-pipe is oxidized by O in water, forming a soluble bicarbonate with CO_2, later forming a crust of insoluble hydrated oxycarbonate.

The leading symptoms of plumbism are motor paresis or paralysis, most marked in the extensor muscles of the forearm ("wrist-drop" or "thumb-drop"), preceded by slight numbness and tremors; neuralgic pains in the flexures of the joints; amaurosis; obstinate constipation, with paroxysms of twisting, grinding pain (lead colic) in the middle abdomen, which is usually depressed and board-like; slow, full, hard pulse; emaciation; sallow, anemic pallor, and afebrile encephalopathy (mental depression and lassitude, headache, dizziness, disturbed sleep, delirium, hallucinations, saturnine lunacy, epileptiform convulsions, and partial coma). Pregnant women subject to plumbism are very liable to miscarry.

A narrow, blue-black line is sometimes noted at the intragingival margin of the gums and teeth, due to a deposition of PbS in the capillaries. If a small area of skin is painted with 6-per-cent. sodium sulphite, it will darken after a few days. The metal is nearly always to be found in the greatly concentrated urine (boil down with dilute nitric acid), especially after the administration of KI for a day or so. Lead escapes five to ten times as much by the bowels as by the kidneys. Men in lead works sometimes drink water containing a little H_2SO_4 as a preventive of plumbism, and alum is likewise of service.

Determination of Lead in the Urine (Lederer).—Five hundred cubic centimeters of the urine to be examined are placed in a porcelain dish (lead free) or in a sufficiently capacious beaker, and about 70 c.c. of concentrated sulphuric acid (free from metals) are added and the combined amounts are heated over a Bunsen burner. Potassium persulphate is added in small portions to the amount of 20 or 25 grams. The urine, which is colored red by the addition of the sulphuric acid, is only slightly yellow when boiling starts; the urine, probably cloudy before, almost instantly becomes clear and transparent. It is then evaporated to about half its volume.

Should the solution become cloudy during evaporation a small amount of concentrated sulphuric acid is added and the boiling continued for about ten minutes. A few crystals of potassium persulphate should be added in case the urine darkens again during evaporation, but care should be taken to remove the burner first to prevent the liquid from boiling over. This procedure is only occasionally necessary as the urine generally remains clear, and slightly yellowish. After the urine has evaporated to about 250 c.c. it is allowed to cool and about 250 c.c. alcohol (90 vol. per cent.) is added. It now is allowed to stand about four hours in a cool place; during this time the smallest amount of lead is precipitated as insoluble sulphate. The evaporation of the urine can also be carried on till less than half its volume remains, but an equal volume of the alcohol should always be added.

The solution is then filtered through a quantitative filter, washed with hydrochloric and fluoric acid, and the beaker or dish carefully washed out with alcohol. Washing the filter is only necessary once to remove coloring matter. A clean small beaker, or test-tube, is put underneath the funnel, and a small hole is punched through the tip of the filter with a clean glass rod. Everything on the filter is then washed down carefully with distilled water from a wash bottle, care being taken not to get too much fluid. If carefully handled not more than 10 c.c. are required. Care also should be taken to remove all particles left on the small glass rod. If considerably more than 10 c.c. are used the solution can be evaporated again if a quantitative determination is wanted. For qualitative determination it does not matter if a few c.c. more or less of distilled water are present. The solution in the test-tube now contains all the lead of the 500 c.c. urine, if such was present, in the form of an insoluble sulphate of lead. The amount is sometimes too small to be observed as a precipitate with the naked eye. It might be only a slight cloudiness, hardly visible. The solution is heated over the Bunsen burner and crystals of sodium acetate are added till the solution appears entirely clear and transparent. After the solution is cleared up it is allowed to cool and hydrogen sulphid gas is passed through it. The slightest yellowish-brown discoloration proves the presence of lead. It is preferable to pass the gas also through a test-tube containing the same amount of distilled water, inasmuch as a slight discoloration can be easily differentiated by comparing the two solutions after the gas has been passed through. Five minutes is sufficient for the passage of the gas.

A great advantage of this method is that even if bismuth is present in the urine it will not interfere with this test, neither will any other substance likely to be present. By comparison with artificial lead solutions containing 1 mg., 2 mg., 3 mg., etc., of lead per liter, a simple quantitative colorimetric method can be established. (One part lead acetate crystal contains 0.54 part of lead.)

ARSENIC.

Chronic arsenical poisoning may result from continuous medication or homicidal administration. It also occurs among smelters, miners, furriers, taxidermists, naturalists, manufacturing chemists, embalmers, and dressmakers (from green tarlatan). Occasional sources of poisoning are from green wall-paper (from less than a grain to a dram per square foot—certain moulds liberate diethyl-arsin), toys, and candies; anilin-dyed lace and clothing; artificial flowers; white enamel; composition candles; carpets; porcelain lamp-shades, and the internal use of the drug for cosmetic effect. Much As may be present in stockings (black especially) and in furs. Scheele's green is employed for wax-tapers, book-covers, cretonnes, calicoes, and tarlatan. Drinking beer made from glucose prepared with H_2SO_4, derived from arsenical pyrites, has led to fatal arsenism. Arsenic is often a contaminant of commercial glycerin and of bismuth (bismuth arsenate). Wheat is preserved for planting with arsenical solutions. Sheep dip is composed of white arsenic, tar, and soft-soap. Lead arsenate is used on foliage to destroy the gypsy moth. There are traces of As in coal-gas. As occurs in some soils as an insoluble Fe compound.

The symptoms of arsenism often simulate enterocolitis or may be like even typhoid fever, with simple "poor health," progressive weakness, and loss of weight. There is gastrointestinal irritation, giddiness, salivation, faintness, nausea, vomiting, and diarrhea; conjunctivitis and edematous puffing of the lower lids; erythema; eczematous, squamous, or vesicular eruptions, and rarely melanosis or keratosis; gradually increasing diffuse multiple neuritis (numbness and tingling of fingers and toes, darting pains in limbs and continuous pain in joints), followed by local (rarely general) pareses and paralyses, chiefly of the leg-extensors and peroneal group, causing "steppage gait." Mania has been noticed rarely. Albuminuria is common, and arsenic may be detected in the urine by Marsh's test after oxidizing all organic matter. In the urine arsenic occurs partly as a very poisonous volatile organic base, which causes convulsions in frogs.

Arsenic eaters (up to 25 grains daily) have a pearly white skin. The face is plump and the eyes are brilliant. The sweat has a strong metallic odor. Sudden death from heart weakness, sometimes preceded by mild dementia, is observed in *habitués*.

MERCURY.

Hydrargyrism is observed among quicksilver miners, smelters, gilders, mirror-makers, hatters, furriers, bronzers, photographers, and manufacturers of barometers, thermometers, amalgams, artificial teeth, and vermilion pigment. It may also arise from fillings in teeth or from medication. The most characteristic symptom of chronic mercurial poisoning is the "intention tremors" (aggravated by motion), with numbness and tingling of anesthetic patches, followed by paralysis ("shaking palsy"), extending gradually from the upper extremities to all the muscles of the body. Another important and early symptom is ptyalism, accompanied by sore and swollen gums and very offensive breath, and rarely followed by falling out of teeth and maxillary necrosis.

Other symptoms are nausea, vomiting, anemia, loss of weight, eczema, erythema. Warm baths and open bowels are important factors in the treatment of mercurialism. Traces of Hg are very commonly found in the viscera as an accumulation from mercurial treatment.

The poison can be detected in the urine next day after giving KI. Acidulate urine with HCl, add Cu filings, heat for five minutes at 50° to 60° C., and let stand till cool. Wash filings, transfer to a shallow dish, and invert over this a watch-glass having on its under surface 1 drop of 1-per-cent. $AuCl_3$ solution. On heating over a low flame the Hg film on the Cu will volatilize and redden the $AuCl_3$. This test is said to react with 1 part of Hg in 10,000,000.

COPPER.

Chronic copper or brass poisoning has been noted among artisans who work in these metals. It may also occur from keeping food in dirty copper vessels—never fatal (oxid soluble in dilute acids), or from color adulterations.

The subjects of this condition complain of an acrid, styptic, coppery taste; of a dry, parched tongue; heat and constriction of the throat, and continuous spitting. Anemia, cachexia, and nerve and muscle symptoms are also quite common. There is sometimes a greenish or purple line at the gum-margins; colicky pains and abdominal tenderness, and bloody, greenish diarrhea, with tenesmus. Greenish perspiration has been observed in the hairy parts. The metal can generally be isolated from the urine.

"Copper colic" is claimed by some as being due to Pb and As in ores and in the commercial metal and solders.

ZINC.

"Zinc fever," or "brassfounders' ague," is characterized by chills, headache, cough, sore chest, cramps in the legs, profuse perspiration, colic, indigestion, diarrhea. Such attacks may recur frequently.

MANGANESE.

The symptoms sometimes presented by workers in Mn include weakness and various pareses, facial paralysis, tremors, exaggerated tendon reflexes, disturbances of voice and speech, and edema of the lower limbs.

ANTIMONY.

Chronic antimonial poisoning may be caused by medication or homicidal administration. There is great depression; clammy sweats, distressing nausea, with occasional mucous and bilious vomiting, dyspnea, diarrhea, muscular cramps, and a small, frequent pulse. The urine is increased in quantity and shows the poison with Marsh's test.

SILVER.

Argyria rarely occurs nowadays from the protracted administration of silver salts or repeated cauterization, and has also been noted in persons engaged in silvering glass. The characteristic sign is a permanent olive, slaty, or gray-brown coloration, beginning in the conjunctiva, around the nails, and the inside of the lips. It is irremediable, and is due to decomposition of Ag salts (chlorids) in the tissues exposed to light, with deposition of the metal. Prominent nervous symptoms are incoordination, tetanic convulsions, and widespread paralysis, without loss of electromuscular irritability.

PHOSPHORUS.

Chronic phosphorus poisoning is seen among people engaged in the manufacture of matches with white phosphorus. The chief lesion is periostitis of the jaw, followed by caries of teeth and necrosis of the bone. Carious teeth predispose. Gastroenteritis, joint pains, peripheral palsies, jaundice, hectic fever, chronic bronchial catarrh, anemia, purpura, and peptonuria may be present. The urinary phosphates are increased. Death depends upon exhaustion. Oil of turpentine and alkaline mouthwashes ($NaHCO_3$) may help to prevent necrosis.

ALCOHOL.

Chronic alcoholism is marked by chronic gastric catarrh, with furred tongue and morning vomiting. Peripheral neuritis and fine tremors of the hands and tongue (worse mornings before a drink) are also noted, as well as a marked moral change. The small veins of the nose and cheek are dilated, and the eyes are red and watery. Delirium tremens is sometimes precipitated by trauma or acute fevers, particularly pneumonia. It is especially common in those addicted to spirits. Hepatic cirrhosis, granular kidney, fatty heart and liver, and a special liability to phthisis and acute infections are among the effects of the long-continued use of alcohol. Epilepsy and insanity occur frequently in absinthe drinkers.

ETHER.

The ether habit is marked by muscular weakness, tremors, cramps, and headache.

TOBACCO.

Smoking is more liable to excite toxic symptoms than chewing. Tobacco smoke contains CO and HCN. Among the most important symptoms of chronic tobacco poisoning are cardiac palpitation and false angina pectoris, rapid or intermittent pulse, granular inflammation of the fauces and pharynx, tremors, giddiness, nervous depression, sclerosis of middle ear, and amaurosis or fluttering scotoma and color-blindness. The dryness of the throat, from the caustic action of the potash in the leaf, favors dyspepsia and alcoholism.

MORPHIN OR OPIUM.

The morphin or opium habit may be developed even in young infants from sucking an *habitué* or from the continued use of soothing syrups. The signs of addiction are chiefly progressive asthenia; disturbed sleep; mental depression; moral perversion; haggard countenance; dry, harsh skin (often needle-scarred); deranged appetite and digestion; neuralgic pains and precordial distress; occasional profuse sweats, preceded by chills and fever; and sexual perversions and impotence. An important point in diagnosis is the marked improvement in the subjective symptoms on giving another dose of the drug. The morphin habit is usually treated by the gradual withdrawal of the drug, substituting other stimulants, such as strychnin, caffein, hyoscin and camphor, along with a nourishing and easily digested diet.

Tollen's Test for Pentose in the Urine of Morphin Habitues.—Add 3 c.c. of a saturated solution of orcin in HCl, to 5 c.c. of urine previously decolorized with bone-black. On heating, a green color appears in the upper part of the urine, gradually extending down.

CHLORAL.

The chloral habit causes impairment of intellection, will, and memory; silly excitability and volubility; persistent drowsiness (very wakeful without drug); indefinite pains and sensory disturbances, and sometimes epileptiform convulsions; anemic, but flushed, face; indigestion, diarrhea; erythema of skin of fingers, with ulceration around nails; feeble, irregular, irritable heart, and polyuria, often stained with bile. This drug may cause delirium tremens. Sudden death is liable to occur.

COCAIN.

A cocain "fiend" is often the result of patent "catarrh cures" or of the attempt to substitute this drug for morphin. Hyperesthesia of the special senses, especially of hearing, is a prominent symptom. There is absolute insomnia or hypnosis, and lewd hallucinations and delusions. The facies is pallid, yellow, and care-worn; the breath very fetid; the skin bathed with perspiration. Hydruria and sometimes incontinence obtain. Cocain eaters sometimes show an ebony blackness of the posterior aspect of the teeth.

ERGOT.

Chronic ergotism occurs from eating bread containing the fungus of rye and darnel. The affection is sometimes epidemic in Spain and Russia. The prolonged use of the drug medicinally may also act as a cause. The patient complains of disturbances of special and general sensation; of pain in the back and painful muscular cramps; of chilly sensations and night-sweats. The skin is pale or earthy, and dry gangrene of fingers and toes appears in the gangrenous form. The temperature is subnormal. Epileptoid flexor spasms and sometimes gradual loss of tendon-reflexes may take place.

DAMAGED MAIZE.

Maidismus, or pellagra, is seen in southern Europe and in the United States (mostly the South). It is due to the fungus, *Reticularia ustilago.* The most marked sign of the disease is a diffuse erythema in the first stage; turning to marked pallor or patches of capillary congestion in the second; and in the third stage the skin becomes dry, shriveled, and dark brown, with exfoliation and suppuration.

TEA AND COFFEE.

Men and women who drink much tea complain of flushings, insomnia, restlessness, headache, vertigo, tinnitus, flashes of light, mental dullness, and confusion. They are mentally exhausted and apprehensive of evil and disinclined to mental exertion. The heart's action is increased and irregular. Muscular tremor, hyperesthesia, and paresthesia are sometimes noted. Chronic coffee intoxication, such as is observed in Brazil, is marked by a state of constant wakefulness and excitement and digestive and cardiac disturbances. Coffee addiction is particularly injurious to children, because of its excessive stimulation of the nervous system.

IODISM.

The administration of iodids in excess leads to running at the nose, sore throat, bronchitis, salivation, gastric irritation, erythematous patches, pemphigus, heavy pain over the frontal sinus, neuralgia and tinnitus aurium, and even convulsive movements. Rapid emaciation may occur.

BROMISM.

Taking bromids for too long a period causes a general lowering of cutaneous and pharyngeal sensibility, fetid odor of breath, mental depression, dulled intellection, and inability to work with the brain. The tongue is coated and the digestion disordered. Quite often there is an eruption of red acneiform papules, bullæ, and pustules, mostly on the face and back. Exhaustion ensues when the bromids are pushed too far.

ACETANILID.

Chronic acetanilid poisoning is observed in persons addicted to the habitual use of headache remedies. It is manifested by dyspepsia, loss of weight, cyanosis (methemoglobinemia), and anemia of a pernicious type.

CYANOGEN.

Chronic cyanogen poisoning is observed among photographers and gilders. It is characterized by headache, vertigo, tinnitus, throat constriction, indigestion, constipation, dyspnea, and precordial pain. The face is pale, the pulse full, and the breath offensive.

CARBON DISULPHID.

Chronic poisoning by this substance is noted in the manufacturers of rubber goods. There is a stage of excitement, followed by depression. The symptoms are chiefly nervous, and include headache; irritability; debility; tinnitus; formication; hyperesthesia, followed by anesthesia; insomnia; sometimes monospasm, monoplegia, or paraplegia, and especially pains in the limbs.

CHROMIUM.

Men who make potassium dichromate are often troubled with ozena and obstinate sores on their hands. These sores slough, forming a deep, foul ulcer, with hard edges.

ILLUMINATING GAS.

The use of gas for cooking has greatly increased the danger from this source. A person continually exposed to leaking gas shows some or all of the following symptoms: Frontal headache (worse on rising), bad taste, anorexia, indigestion, abdominal pains, constipation, lassitude, vertigo, tinnitus aurium, amnesia, sometimes convulsions, anemia, and irregular fever (up to 104° F.—sometimes mistaken for malaria or typhoid). The patient improves in the fresh air. In case of doubt, a spectroscopic test of the blood, diluted with distilled water, should be made for CO-hemoglobin. Illuminating gas, escaping from street mains and passing into dwellings (more in winter than in summer), may lose its odor by diffusing through the soil.

POISONOUS BITES AND STINGS.

The venom that passes from the poison-gland of a dangerous reptile through the hollow fang into the wound made by a bite quickly causes the part bitten to become dark, swollen, and very painful. The chief general symptom is prostration; but dyspnea, jaundice, cold sweats, bilious vomiting, delirium, and convulsions may occur. The wound should be promptly drained by incision and cupping or sucking. There is no danger in sucking out snake-venom or even in swallowing it, providing there are no cracks in the mucous membrane about the lips and tongue. The local injection of liquor ammonia and of a strong solution of potassium permanganate or chlorinated lime is recommended by various authorities. An intermittent ligature should be applied above the wound to prevent as much as possible the introduction of the poison into the general circulation. Alcoholics, strychnin, atropin, and other stimulants should be administered in full doses, but not *ad libitum*. Calmette's antivenene, in frequently repeated injections of 10 to 20 c.c., has saved life when used promptly. It is a neurotoxin and does not neutralize rattlesnake venom (a hemorrhagin). The poison of venomous reptiles consists essentially of a pepton and a globulin.

The bite of a rabid dog is liable to lead in a few weeks to the development of hydrophobia. Thorough excision of the entire wound area is the safest procedure in these cases. Next best is to encourage free bleeding and then to cauterize the wound thoroughly with strong HNO_3, neutralizing any excess with baking-soda or ammonia. The acid is more penetrating in its action than silver nitrate, commonly used for this purpose.

The sting of bees and ants, and more especially wasps and hornets, may lead to erysipelatous swelling, suppuration, gangrene, and even death. The treatment is to remove the poison as much as possible by wet-cupping, then neutralize the acid present in the poison with ammonia or baking-soda. The mere application of one or other of these is usually sufficient in mild cases.

Toxicodendrol, the active principle of poison ivy, poison oak and swamp sumac, is present in all parts of these plants, even in the microscopic hairs which are given off and float in the air. One-thousandth mg. of this fixed oil may cause dermatitis in susceptible individuals, after a latent period of 1 to 9 days. An alcoholic solution of lead acetate is a good chemic antidote. Vaselin and other ointments dissolve and spread the poison. The English primrose produces similar cutaneous effects.

QUESTIONS ON TOXICOLOGY.

1. Explain the principle of the ligature in cases of snake-bite.
2. How may a small dose of arsenic prove fatal, while a larger one does not?
3. How distinguish between ante-mortem and post-mortem imbibition of poisons by the viscera?
4. A body dead for some weeks shows yellow stains in the viscera from arsenic; orange from antimony; black from mercury. Explain.
5. Bodies have been exhumed some years after burial and found in a good state of preservation. What poisons should be suspected?
6. What is the antidote for concentrated lye?
7. Explain curdy vomit in poisoning by silver or lead salts.
8. In a certain case of poisoning a blue vomit was noticed. Explain.
9. Write equation for the antidotal reaction of ferric hydrate with arsenous oxid.
10. What common syrup may be the source of antimonial poisoning?
11. Name six common household antidotes and their special uses.
12. What causes the yellow staining of the tissues in nitric acid poisoning?
13. In a case of poisoning white fumes are produced by dipping a glass rod in HCl and holding it near the mouth. Explain.
14. How does sodium thiosulphate antidote chlorinated lime?
15. Why should fats and oils be avoided in poisoning by phenol or phosphorus?
16. What acid chars the tissues and stomach-contents?
17. What gaseous poison accumulates in and around beer-vats?
18. Why is it generally well to empty the stomach after giving the antidote?
19. What possible danger is there from the use of carbonates and bicarbonates as antidotes for mineral acids?
20. How prove the presence of P in match-heads?
21. Name five poisons that may cause fever.
22. Compare the symptoms of opium and belladonna poisoning.
23. Compare the symptoms and treatment of poisoning by corrosive acids and by caustic alkalies.

24. Mention the chief points in the diagnosis of the poison taken gained by looking into the patient's mouth.

25. What effect would a hot-sulphur bath have on a person who has been "leaded"?

26. Why should soapsuds and alkalies (except lime-water) not be given as antidotes for oxalic acid?

27. How may the fermentation of starch under wall-paper aid in causing arsenical poisoning?

28. Why is red P much less poisonous than the ordinary yellow form?

29. What chronic poisoning resembles malaria? Typhoid fever?

30. What poison may be naturally present in potatoes? In corn? In rye?

31. What poison might be mistaken for epilepsy?

32. Describe the resemblances between poisoning by phenol and by opiates.

33. Mention ten poisons which may be noted in the breath.

34. How may ferrosilicon (impurities, phosphorus and arsenic), stored in the hold of a ship, give rise to fatal poisoning in steerage passengers?

PHYSIOLOGIC AND PATHOLOGIC CHEMISTRY.

CHEMIC COMPOSITION OF THE HUMAN BODY.

THE elements of the body are generally those of low atomic weight and wide distribution in nature. Of the 21 elements found normally in the human body, 17 are constantly present. C (13½ per cent.), H (9 per cent.), N (2½ per cent.), and O (72 per cent.) constitute 97 per cent., by weight, of the body, chiefly in combination, though the last three also occur free in the blood, stomach, and intestines, N and O being inhaled or swallowed and H arising from putrefactive processes (leguminosæ and butyric acid fermentation).

The following elements are likewise essential body ingredients in the percentage mentioned: Ca (mainly fixed in nuclei), 1.3; P, 1.15; S, $\frac{1}{7}$ of 1 per cent.; Na, 0.1; Cl and F, each, $\frac{1}{12}$ of 1 per cent.; K, $\frac{1}{40}$ of 1 per cent.; Mg (extranuclear), $\frac{1}{80}$ of 1 per cent.; Fe, 0.01 (3 gm. altogether); Si, $\frac{1}{500}$ of 1 per cent.; Mn, 0.0005 per cent.; and I, a trace. Na is present chiefly in the fluids of the body, which it renders alkaline, while K occurs, for the most part, in the solid tissues, because membranes absorb it better. There is no K in cell-nuclei or nerve cells. It is condensed in striated muscle in the contractile dim bands. S occurs as taurin in the muscles and bile, as H_2S in the feces, and as sulphates in the urine. Fe is the coloring matter of blood, bile, hair, and skin pigment. It has great affinity for O, which it carries from the lungs to the tissues. It is present in the liver as the organic compounds ferratin and hepatin, and is probably utilized in the construction of hemoglobin. Organic Fe (combined with nucleins) differs from that of artificial compounds in not reacting with $(NH_4)_2S$, nor being extracted with alcohol.

A considerable trace of I (iodothyrin in cell-nuclei) is met with in the thyroid. It seems to exert an antitoxic action and to increase the metabolism of proteins. A deficiency of thyroidin leads to the peculiar disease myxedema. Traces of Mn, As, Cu, Pb, Al, and Br are occasionally encountered in the liver, which acts as a buffer for the rest of the system, protecting it from poisoning from without and from within. Arsenic (Gautier) is a normal constituent of the body (chiefly as nuclein iodid) in the thyroid and thymus, skin, hair, and brain.

Of the inorganic compounds that help to make up the body, H_2O is most abundant, constituting 67.6 per cent., by weight, of the whole, and ranging from 0.4 per cent. in the enamel of teeth to 99.5 per cent. of saliva. Water is the system solvent for absorption, secretion, and excretion. It makes the tissues soft, flexible and elastic, and by evaporation aids in regulating animal heat. About a pound of H_2O is formed daily in the body by the oxidation of H compounds, and 3 kg. are eliminated by the kidneys, lungs, and skin. A loss of 5 or 6 per cent. of water, as in cholera, renders the blood viscid and slow of current, irritating to the nerves, and causing convulsions.

The nascent H produced by cell-decomposition probably unites first with O, forming H_2O_2; and this has been found in the sweat and other fluids. The peroxid thus formed quickly breaks down into H_2O and nascent O.

Of compound gases, CO_2, H_2S, and CH_4 are most important. The first is formed in living cells by internal oxidation (much increased by exercise), and also during fermentation in the alimentary tract. It is present chiefly in the blood in combination with Na. H_2S, formed by the putrefaction of S-containing proteins (eggs), occurs mostly in the bowels, but may also be found in old abscess-cavities. CH_4 is derived from acetates, the fermentation of cellulose, or protein putrefaction, and is the principal gas giving rise to flatulence and colic. It is the only hydrocarbon found in the body.

Inorganic salts constitute about $\frac{1}{20}$ by weight of the total solids in solution. The chlorids of the body (Hall) preside over the chemic regulation of the tissues and fluids and prevent (detoxication) accumulation of toxic substances. Whenever poisons threaten the security of the economy, chlorids are despatched thither to increase the molecular tensions of the region affected. Decrease of chlorids in foods causes the retained chlorids of the tissues to release their hold upon them and to be eliminated in conjunction with these toxic substances.

The chlorid of Na is present in all the body-fluids (0.65 per cent. in blood-serum; 0.5 per cent. in lymph; 200 gm. in body) and in all the tissues except enamel, and is of great importance in promoting osmosis and diffusion. KCl is most abundant in blood-corpuscles and muscles. $CaCl_2$ is also a necessary ingredient of the blood. The chlorids generally pass through the body unchanged, except the small proportion of NaCl used up in making HCl. CaF_2 is present chiefly in the bones and teeth, especially the enamel (2 per cent.).

The phosphates of K, Na, Ca, K_2HPO_4, Na_2HPO_4 (2.5 kg.), and Mg are present in nearly every tissue and fluid of the body, in loose combination with proteid compounds. The alkalinity of the blood is due partly to the secondary sodium phosphate, Na_2HPO_4, which is partly changed by CO_2 to the primary phosphate, NaH_2PO_4, to which the acidity of the urine is largely due. $FePO_4$ is present in the bile, the gastric and intestinal juices, and in the pigment of hair and epithelium. $CaH_2(PO_4)_2$ is held in solution in blood and milk by protein constituents.

The carbonate of Ca is an essential component of bones and teeth. The otoliths of the internal ear are composed of crystalline $CaCO_3$. The carbonates of K and Na aid in rendering the blood alkaline. They take up CO_2, forming bicarbonates. Ammonium carbonate is found normally only in traces in the blood. The amount is greatly increased in cholera, with ammoniacal breath and stools.

NH_3 is produced in the tissues by the union of N and H. It combines with CO_2 to form ammonium carbamate, which is dehydrated in the liver into urea.

A small quantity of the sulphates of K, Na, and Ca is found in nearly every part of the organism. Very minute quantities of SiO_2 are obtained from the blood, urine, bones, and hair. Silicic acid seems to bear the same relation to connective tissue as P does to nerve tissue. There is comparatively more silica in the tissues of young persons than in adults.

The non-nitrogenous organic constituents, or proximate principles, of the body include CH_4, dextrose, lactose (breast-milk), inosit, pentoses, glycogen, fats, and fatty acids.

Dextrose is the chief sugar of the blood and muscles. There is at least 0.1 per cent. in the blood, even during starvation. It is derived mainly from starch and cane-sugar, but is also in part a derivative of proteins (amino-acids), which may be made to yield artificially as much as 60 per cent. of dextrose. Pentoses form an integral part of the nucleoproteids of the body, being obtained most abundantly (2.5 per cent.) from the pancreas.

Inosit $[C_6H_6(HO)_6]$ is present in muscles and viscera. It can be oxidized and utilized by diabetics. Lactose is a leading ingredient of mothers' milk (and amniotic fluid), and is likely to be found in the blood and urine whenever the milk-flow is obstructed. The glucosid, jecorin, found in the liver and the blood, yields dextrose on decomposition. Indican is a brownish, bitter, syrupy glucosid derived from indol, a weak base produced by the pancreas and during intestinal putrefaction. The production of indol depends largely on the activity of the colon bacillus, which ferments carbohydrates before acting on proteins. Baumann states that both indol and skatol result from decomposition of a non-proteid substance, soluble in ether containing alcohol.

The body-glycogen is about equally distributed in the muscles (0.4 to 0.8 per cent.) and the liver (up to 15 per cent.). This supply is drawn upon by hunger and cold. Muscular work also causes a rapid conversion of glycogen into dextrose (dextrins and maltose are intermediate products). The glycogen is probably derived in part from tissue-proteins. Glycogen is found in tumors in amount proportionate to malignancy. The carbohydrates of the body, particularly glycogen, are markedly decreased in infectious diseases.

The body-fat (2.5 to 25 per cent.) is all in a fluid condition, owing to the considerable proportion (67 to 80 per cent.) of olein with the palmitin and stearin. It occurs as an emulsion in the circulating fluids and in drops in special cells (adipose); also in the interior of tissue cells. It is produced by the storing of food fats, as a derivative of protein and carbohydrates, and as a product of metabolism in connective tissue and other cells. The loss of subcutaneous fat causes the wrinkles of old age. The yellow color of the corpora lutea is due to lipochromes or luteins.

Lecithin is a waxy phosphorized fat present in every living cell, and most abundant in the brain and nerves. Boiling with acids or alkalies breaks it up into cholin, fatty acids, and glycerophosphoric acid. It swells in distilled water, giving rise to the "myelin forms" of nerve-tissue.

$C_{44}H_{90}NPO_9$ (lecithin) $+ 3H_2O = 2C_{18}H_{36}O_2$ (stearic acid) $+ C_3H_9PO_6$ (glycerophosphoric acid) $+ C_5H_{15}NO_2$(cholin).

Lecithins (lecithanes) serve along with albumins in giving the necessary viscosity to colloid solutions. They are readily influenced by ions, and take a leading part in cellular metabolic changes. Lecithin appears to stimulate body-growth, and is found in largest amounts in tissues undergoing active development. It is abundant in all neoplasms, and is destroyed by X- and radium- rays.

Protagon is obtained from the brain. It is a crystalline body containing lecithin and cerebrin, $C_{17}H_{33}NO_3$. The latter is a glucosid, breaking up into d. galactose.

Organic acids are present in combination with alkaline and earthy bases, chiefly in the excretions (often as under-oxidation products) and in fermentation and putrefaction compounds. HCOOH is found in sweat. The formates are much increased in the blood and urine in fever, diabetes, leukemia, and wood-alcohol poisoning. CH_3COOH is often found in feces. When absorbed from the intestine it is burned into CO_2 and H_2O. It is present in the blood, sweat, and urine in leukemia and diabetes. Diacetic acid ($CH_2CH_3COCOOH$) and beta-oxybutyric acid ($CH_3.CHOH.CH_2COOH$) probably result from fat-metabolism. They are increased in starvation and diabetes, neutralizing the blood and causing coma and increase of NH_3 in the urine. $(CH_3)_2CO$ is increased in the blood and urine whenever there is excessive decomposition of fat, as in diabetes. C_2H_5COOH, from protein putrefaction, is found in the sweat, bile, and sometimes in the stomach. C_3H_7COOH, from the putrefaction of proteins and carbohydrates, is found in the stomach-contents in hypochlorhydria, and in the intestinal evacuations. A bad taste in the mouth is frequently due to this acid. $H_2C_2O_4$ is a metabolic product derived chiefly from nucleins and gelatins.

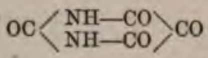
The foul-smelling isovaleric acid, C_4H_9COOH, from proteid decomposition, is noted in sweating feet and sometimes in the urine in certain grave diseases. Capric and caprylic acids are found in the perspiration and in milk-fat; palmitic, oleic, and stearic acids are present in milk-fat and adipose tissue. The very slight acid reaction of bile is due to these three acids. $C_3H_6O_3$, from fermented milk, is of common occurrence in the stools of infants. Sarcolactic (paralactic, or right ethidene) is found in the muscles, blood, and blood-glands, and is derived from protein tissues, and when in excess causes fatigue. The acidity of the flesh and viscera, which develops after death, is due to this acid. It causes the formation of KH_2PO_4, with the coagulation of myosinogen, during *rigor mortis*. Excess of absorbed fatty acids has a sclerogenic effect.

The essential nitrogenous compounds of the human body are mostly globulins, serum-albumin being the main exception. Phenol, indol (C_8H_7N), and skatol ($C_8H_5CH_3NH$) are formed by putrefaction of proteins in the intestines and, with H_2S, give the ordinary fecal odor to the stools. Leucin ($C_5H_{10}NH_2$-$COOH$) and tyrosin [$C_6H_4.OH.C_2H_3(NH_2)COOH$] are normal products of tryptic digestion of hemipeptons. Like other amido-acids, they are oxidized in the liver into urea, with production of heat; when the liver is diseased (acute yellow atrophy, P poisoning) they appear in the urine. Leucin is also found in decomposing epithelial matter. Glycocoll and other amido-acids are an important source of sugar.

Urea [$(NH_2)_2CO$] is the chief end-product of nitrogenous metabolism in mammals, and is formed, perhaps, in all tissues where proteid decomposition takes place. Its principal site of origin is the liver, where it is formed by dehydration of ammonium carbamate, which is produced in the tissues by the union of CO_2 and NH_3; also from leucin and glycocoll. The amount of urea normally ranges from 0.08 to 0.16 per cent. in the blood, muscles, and viscera; 0.67 per cent. in the kidney. When the kidney fails to functionate (uremia) these relative proportions may be nearly reversed. The ureids are crystallizable bodies from which urea can be formed. They comprise monoureids (alloxan and all oxanic, dialuric and barbituric acids) and diureids, such as uric acid and murexid, which yield urea and monoureids.

Creatin, or methylguanidin acetic acid ($HNCNH_2NCH_3$-CH_2COOH), is a product of proteid decomposition, especially of the muscles. It is excreted in the urine as creatinin: creatin less water. Creatin can be broken up, with hydrolysis, into urea and sarcosin, $NH.CH_3.CH_2.COOH$, but most of the creatin is probably decomposed into NH_3 before leaving the muscles.

The purin, or alloxuric, bodies contain both the radical (N_2C) of urea and that (N_2C_4) of alloxan:—



$$\mathrm{OC}\left\langle\begin{array}{l}\mathrm{NH{-}CO}\\\mathrm{NH{-}CO}\end{array}\right\rangle\mathrm{CO}$$

Hypoxanthin, or sarcin $= C_5H_4N_4O$; xanthin $= C_5H_4N_4O_2$; uric acid $= C_5H_4N_4O_3$ (trioxypurin, lithic acid); purin $= C_5H_4N_4$; adenin $= C_5H_5N_5$; guanin $= C_5H_5N_5O$. Nucleins cleave into a protein and nucleic acid, and the latter into phosphoric acid and alloxuric bodies, uric acid being a higher oxidation product than xanthin or hypoxanthin. Through oxidation and hydrolysis uric acid can be decomposed into two molecules of urea and one molecule of oxalic acid, and when administered to a mammal it is changed by the liver into urea. Heteroxanthin is methylxanthin; theobromin of cocoa is dimethylxanthin and isomeric with paraxanthin; caffein is trimethylxanthin; carnin is dimethyluric acid. The alloxur bodies are normally present in the fluids and tissues of the body and in urine. The normal daily amount of uric acid excreted in the urine is from 0.4 to 0.8 gm.; of purin bases, 0.1325 gm. (quadrupled in leukemia). The quantity of uric acid and other alloxur bodies is increased by the ingestion of tea, coffee, cocoa, and nuclein-containing foods, such as young flesh and meat extracts. Reduced alkalinity of the blood, as in winter from eating meats freely, throws uric acid out of solution, to collect in the more acid tissues (spleen, liver, and joints). With the vernal tide of alkalinity (due to freer sweating, with excretion of fatty acids) these deposits are swept out in the blood-current, irritating the nerves and giving rise to "that tired feeling."

Uric acid is normally destroyed in the human organism by oxidation into urea, chiefly in the muscles, kidneys, liver, spleen, and blood. Deficient oxidation is the underlying factor in goutiness, or the "uric acid diathesis." The endogenic (nucleinic) uric acid amounts to about one-fourth of the whole, but there are marked, though constant, individual differences (Long). The exogenic uric acid is derived from oxypurins (nucleins) and aminopurins (purin bases) in the food. An attack of arthritic gout occurs when the synovia is impregnated with uric acid to the extent of 1 to 2500 (Roberts). The tophi of gout are white, rounded, plaster-like masses of sodium biurate, with small amounts of lime salts, in the joints, tendons, and cartilages. The proportion of sodium salts is greatest in these fibrous tissues. Potassium salts prevent such precipitations. There is a close relation between uric acid and many cases of bronchial asthma. These attacks are sometimes accompanied by diarrhea and bilious vomiting, and are noteworthy for their periodicity (usually in the early morning).

The pyramidin bases, allied to the purin bases, are thymin, cytosin, and uracil. Nucleic acid splits up into these two kinds of bases, phosphoric acid and carbohydrates (pentoses, hexoses, glucothionic acid).

Experiment.—Prove futility of lithium compounds in uric-acid conditions by treating solution of Na_2HPO_4 (same salt in blood) with a little $Li_3C_6H_5O_7$ solution. Warm slightly and note white ppt. of Li_2HPO_4.

Cholin ($NC_2H_4OH(CH_3)_3OH$ = trimethyl-oxyethyl-ammonhydroxid) and neurin (cholin — H_2O) are amins of olefins produced in the intestines from proteins by the action of bacteria. Glycocoll, CH_2NH_2COOH, is a normal decomposition product from proteins, and is easily manufactured from gelatin. It exists in the bile as glycocholic acid, and in the urine with benzoic acid as hippuric acid (conjugated in liver) after taking benzoic acid or its derivatives.

Taurin ($NH_2C_2H_4SO_3H$) is found in the spleen, muscles, suprarenal capsule, and in bile as sodium taurocholate. Fellic acid ($C_{23}H_{38}O_4$), cholic acid ($C_{24}H_{40}O_5$), and choleic acid ($C_{24}H_{40}O_2$) are probably derived from the non-nitrogenous moiety of proteids. By synthesis with taurin and glycocoll in the liver they form taurocholic and glycocholic ($C_{26}H_{43}NO_6$) acids, the salts of which are known as the bile-salts and have the function of dissolving the more insoluble fatty acids and soaps produced by steapsin.

The two bile-acids always occur as Na salts in bile and are probably oxidation products of protein. These conjugated acids give rise on decomposition to cholalic or other allied acid and an amido-acid (amido-acetic = glycocoll, or amido-ethyl-sulphonic = taurin). Cholalic acid oxidizes into one ketone and two aldehyd groups, which have a reducing power on hemoglobin; hence the injurious effect on the corpuscles of cholemia.

Cholesterin ($C_{27}H_{45}OH$) is probably an accumulation product of the hydrolysis of carbohydrates by the epithelium of the gall-bladder and bile passages, and is also a product of nerve metabolism. It is converted into stercorin (coprosterin) in the bowels. When more is made than can be utilized, it constitutes waste-material and forms gall-stones, their formation being favored by catarrhal conditions, stagnation of bile, and the presence of attenuated bacteria.

Bilirubin ($C_{16}H_{18}N_2O_3$) is the ordinary coloring matter of human bile. Bilirubin is hematin less Fe + H_2O, and is isomeric with hematoporphyrin. On reduction with nascent H, bilirubin becomes stercobilin (urobilin). Various oxidation products are biliverdin (green), bilicyanin (blue), and bilixanthin (brown-yellow).

Melanins are black and brown S-containing pigments found in the hair and in the skin of the negro, in the choroid and in melanotic tumors (phymatorhusin). They can also be derived by hydrolytic decomposition of peptons (peptomelanin) and albumins (melanoidins). The melanins of the hair and skin are readily dissolved by alkaline hydrates.

The solid constituents of the body comprise about five times as much organic as inorganic matter. The fats may be extracted by treating with CS_2 or ether, then the so-called extractives (organic acids, bases and salts) are dissolved out by treating successively with alcohol and water, leaving an elastic corneous mass of protein. The primary cell constituents are inorganic salts, glycogen, cholesterins, lecithins, and proteins (glyco- and nucleo- chiefly). The secondary constituents include fat, pigments, etc.

The moving cells and the fixed tissues of the body are composed of protoplasm: that is, of proteids with such a molecular arrangement as admits of the phenomena of life. Protoplasm contains 80 to 85 per cent. of water. The nucleoproteids of protoplasm are chiefly compounds of pseudonuclein; those of the nucleus are compounds of cell nucleins and nucleic acids. The active nucleus and spongioplasm appear to draw their nutriment from the passive cytolymph in the cells. The native alkalinity of the entire adult body is equivalent to 60 gm. NaOH. Horror autotoxicus is the term applied by Ehrlich to the inherent cellular power which guards the organism against autolysis: that is, the solution and digestion by its own fluids which takes place after death.

The final products of body decomposition after death are such simple substances as CO_2, H_2O, NH_3, H_2S, and mineral chlorids, sulphates, and phosphates. There are a large number of intermediate products, the most important being the cadaveric alkaloids or ptomains. The fetid odor of gangrene is due to fatty acids, H_2S and NH_3.

The soap-like conversion into adipocere, which dead bodies sometimes undergo, is due to the formation of Ca and NH_4 salts of palmitic and stearic acids, through the agency of bacteria. The surface of the dead body within and without becomes coated with a whitish crust of crystallized calcium phosphate. The ashes left from cremation (30 to 90 minutes; temp., 2500° F.) weigh from 4 to 6 pounds.

BONES.

Adult bone contains 69 per cent. of earthy matter, of which $Ca_3(PO_4)_2$ constitutes 59 per cent. (3 molecules to 1 of carbonate); $CaCO_3$, 7 per cent.; $Mg_3(PO_4)_2$, 1.3 per cent., and CaF_2 and soluble salts, 1.5 per cent. The bones of infants and young children contain much less mineral matter; hence are less brittle. The compact portions of bone contain more mineral matter than the cancellous. Undried bone is from 14 to 44 per cent. water. The bones and the muscles each constitute nearly half the whole mass of the body.

The animal matter of bones, termed ossein (12 per cent. of undried bone: a mixture of collagen and elastin), is closely combined with the inorganic salts, so that the shape and size of a bone are retained after these salts have been removed with acids. There is also 15 per cent. of fat, chiefly in the marrow. The yellow marrow may contain as much as 96 per cent. fat. The red marrow owes its color to large numbers of erythrocytes. It also contains peculiar iron compounds, which have to do with hematogenesis.

Experiment.—Place a rather long and narrow bone in 10 per cent. HNO_3. Remove the bone in a day or two and tie it in a knot.

Experiment.—Prove presence of phosphates in acid solution with $(NH_4)_2MoO_4$.

Experiment.—Test another portion of same solution for Ca and Mg as follows: First treat with $FeCl_3$, added little by little, testing after each addition with NH_4HO until this gives a ppt. which is no longer white, but yellowish; then add Na_2CO_3 until nearly neutral; and finally ppt. the ferric phosphate with 1 or 2 gm. of $BaCO_3$; warm and filter, and ppt. Ba from hot filtrate with dilute H_2SO_4. Test the second filtrate for Ca by rendering alkaline with NH_4OH and adding excess of $(NH_4)_2C_2O_4$. Test the third filtrate for Mg with Na_2HPO_4.

Experiment.—Heat some fragments of bone in a dry test-tube; note that H_2O and NH_3 are evolved, and then bone-oil and inflammable gases, leaving bone-black and bone-ash. Take up a little of the black mass on a Pt loop, burn away C, and test for carbonate with an acid.

In old age the bones become more porous; hence more fragile. In most bone diseases (rickets, osteomalacia, and osteoporosis) the lime-salts are diminished, while the organic constituents undergo qualitative changes. The phosphates are permanently reduced in the urine after castration of man or woman, thereby benefiting osteomalacia.

TEETH.

The composition of teeth is much like that of bone, dentin containing 26 to 28 parts of animal matter (collagen) and 64 to 68 parts of mineral, with 6 to 10 per cent. of water. Cement, or crusta petrosa, is true bone. Enamel is the hardest tissue in the body, containing only 3½ per cent. of organic matter (no collagen), and composed chiefly (90 per cent.) of calcium phosphate and fluorid. The enamel of young infants contains from 77 to 84 per cent. of mineral matter.

Experiment.—Estimate the water in a freshly extracted tooth: Weigh out a gram of the crushed tooth in a tared porcelain crucible, and place in the air-bath at 95° for an hour. Remove, cool, and weigh, and return to the oven for another half-hour; then cool and weigh again. If the last two weights correspond, the tooth is dehydrated; otherwise it should be again heated until the weight is constant.

Experiment to Estimate Organic and Inorganic Matter.—Place the dehydrated product of the preceding experiment on a triangle, cover the crucible, and burn the organic matter; then remove, cover, and calcine at a red heat till the ash is nearly white. Cool and weigh.

Experiment.—Place a tooth in 10 per cent. HNO_3 for two or three days. Then pour off the acid mineral solution and, after neutralizing with NH_4HO, test it for phosphates with $(NH_4)_2MoO_4$; and boil the organic residue with water, forming a gelatin-jelly on cooling.

Acid substances—Hg, As, alum, and H_2O_2—are especially injurious to the teeth. Liquid medicines containing acids, like tincture of iron, should be taken well diluted through a glass tube. Eating much candy injures the teeth by reason of the lactic acid produced by fermentation.

The common brown variety of dental caries is said to be due to nascent HCl; the white or rapid variety to HNO_3, formed by combination of NH_3 and nascent O evolved during fermentation; the black variety may be caused by H_2SO_4, formed by the nascent O and H_2S of putrefaction. It is more probable, however, that the color of caries depends upon its rapidity—the slower, the darker.

Acids act more readily on dentin than enamel; hence the tendency of a cavity to enlarge centrally. These acids are formed by the action on foods of various fungi and bacteria. Local inflammations, mental strain, pregnancy, and lactation predispose to caries.

The tartar of teeth is a gray, brown, or yellow deposit from alkaline saliva, and consists chiefly of $Ca_3(PO_4)_2$, with a little $CaCO_3$ and more or less organic matter, molds and bacteria, silica, and alkaline salts. The salivary secretions hold lime-salts in solution by the aid of CO_2. On passing into the mouth this is neutralized by NH_3 and other alkalies of putrefactive origin, and the lime-salts are precipitated as tartar. Rarely a yellowish deposit is composed of sodium urate.

MUSCLE.

Three-fourths of muscular tissue is water. Muscle plasma is made up of 20 per cent. myosin ("paramyosinogen," more coagulable) and 80 per cent. myogen ("myosinogen," less coagulable). Four-fifths of the solid substance is proteid; the remainder consists of extractives (urea, creatin, xanthin, uric acid, etc.) and inorganic salts. The ash (1 to 1.5 per cent.) of muscle contains over 3 per cent. of Mg and between 2 and 3 per cent. Ca, but K and phosphoric acid predominate. Muscle-juice is produced only after autolysis of proteins begins. The stroma of muscle is composed of nucleoproteid and coagulated proteid, yielding 2 per cent. gelatin. The sarcolemma consists of an albuminoid resembling elastin. Fat is interfibrillar and in the sarcoplasm. Muscle pigment is derived from hemoglobin. The carnic acid ($C_{10}H_{15}N_3O_5$) of muscle is combined with P to form phosphocarnic acid, or nucleon.

Nucleoproteid is most abundant in plain muscle; least so in voluntary muscle. Paramyosinogen coagulates at 47°; myosinogen, at 56°. Myosinogen is not a typic globulin, since it is soluble in water and not pptd. by dialysis. Paramyosinogen passes directly into the clotted condition of myosin, or muscle-fibrin; myosinogen first passes into a soluble condition (coagulable by heat at 40°) before it clots.

The interfibrillar glycogen (changed to sugar) is the chief source of muscular energy and tonicity. It is derived from proteins as well as carbohydrates. During muscular contractions it is transformed to erythro-, then achroo- dextrin, and this into maltose and then glucose. The latter is then decomposed by a specific ferment activated by a pancreatic kinase, the final products being CO_2 and H_2O, with formic acid and acetic aldehyd as intermediate products. Glycogen disappears from the musculature in inanition, and more rapidly during work.

The reaction of resting muscle is neutral or slightly alkaline (heart muscle always acid). During contractions it becomes acid (most marked with insufficient oxidation), owing to the sarcolactic acid evolved by the breaking down of proteids and glycogen, and from KH_2PO_4 formed by the free acid acting on K_2HPO_4. Muscular fatigue is ascribed to the irritating effects on the nerve-plates of an excess of sarcolactic acid and extractives.

Experiment.—Test fresh muscle-juice with litmus and lacmoid. It is commonly amphoteric, from the presence of mono- and di-calcium phosphates and of sarcolactic acid. Show that an old meat extract is acid.

Contractile tissues will not contract in pure solutions of non-electrolytes. Ions produce contractions by affecting the physic condition of protoplasm or the rapidity of chemic processes. Na ions stimulate contractions; Ca and K retard or inhibit rhythmic contractions, but a minimal amount must be present if the contractions are to continue for any length of time. H and OH aid the action of Na ions catalytically.

Rigor mortis is said to be due to coagulation of myosin and myogen through the action of fibrin ferment, forming a clot. *Rigor mortis* usually begins two hours after death, reaching its maximum two hours later. It appears sooner in hot weather and after exertion, and later in cold weather. The final disappearance of post-mortem rigidity is ascribed to the action of acids which render myosin soluble—or to an enzyme (autodigestion).

NERVE SUBSTANCE.

The composition of brain and nerves differs from that of other organs in containing (in addition to albumin, globulin, nucleins, and nucleoproteids) a large proportion of phosphorized fatty compounds. The white substance is more fatty and less aqueous than the gray.

There are three groups of phosphorized fats in the brain: lecithins (very unstable; in combination with cerebrosids as protagon), kephalins (very soluble in ether), and myelins (most stable). The cerebrosids (cerebrin, kerasin, encephalin) are nitrogenous substances in the white matter; they contain no P, and on hydrolysis yield galactose, or "brain-sugar." The amount of water normally in the brain is from 71 to 83 per cent.; in the nerves, 72 per cent. The nervous system of children has more water, comparatively, than in adults. Normal nerves contain about 1 per cent. of P and about the same proportion of inorganic salts, chiefly phosphates and KCl. The neurolemma and neuroglia consist mainly of neurokeratin. Gray nerve matter is always acid; white, neutral or slightly alkaline. The sp. gr. of the brain is about 1.038; of the spinal cord and nerves, 1.034.

In nerve degeneration P and lecithin are diminished, while fat and extractives (neurin, cholin, fatty acids, and purin bodies) are in excess. Cholesterins are found in nerve tissue, both free and combined. According to Sajous, the entire nervous system is built upon the plan of fibrils containing blood-plasma, surrounded by a layer of myelin. The main constituents of these bodies, the oxygen of the plasma and the phosphorus of the myelin, are thus brought into contact, and nervous energy is liberated.

The achromatic nerve substance is the most essential part, and degenerative changes in it are irreparable. The fibrillar portion appears to be a conducting medium. The non-organized portion (trophoplasm) is held by Marinesco to be the seat of nutritive phenomena. The chromophile substance is perhaps a reserve of nutrient material. Chromatolysis accompanies fatigue or poisoning of neurons and primary and secondary nerve degeneration.

The nerve stream (action current) may depend on a rearrangement of ions propagated from point to point. Mathews holds that a nerve impulse is a gelation wave due to electric change—negative (anelic) in motor nerves. Anions generally stimulate, and cations depress.

The rods of the retina contain a substance called visual purple (rhodopsin), which bleaches on exposure to light, the color being restored in the dark. It is probable that the changes in the rods and cones, perceived by the brain as visual effects, are chemic in nature. According to the Young-Helmholtz theory, the retina contains three substances corresponding to the primary colors: red, green, and violet. The sensation of color is due to chemic changes in these substances brought about by the selective action of light rays of a certain wave length. A person who is color-blind is deficient, usually from birth, in one of these retinal substances, and commonly is unable to distinguish red from green.

EPIDERMAL STRUCTURES.

Epithelia, nails, and hair are composed chiefly of keratins. According to Simon, the combination of these with cholesterin fats serves to protect the skin surfaces from the attacks of ever-present bacteria. There is a large amount of silicic acid in hairs, which stiffens them. Human hair contains 2.5 per cent. S, in part loosely combined.

Experiment.—Boil some hairs or nail-parings with a little KHO. Then add HCl and note odor of H_2S.

The granular pigment melanin (an organic compound of S and Fe) is present in hair, the rete mucosum, and the pigment-layers of the retina (fuscin), choroid, and iris (only on back of iris in blue eyes). It is derived from blood-pigment, and serves as a protective screen against too bright sunlight, which develops more of it. Pigment formation is likewise stimulated by the electric light, X-rays, and the prolonged use of poultices and hot compresses. Melanotic tumors contain considerable of this pigment. The depth of the color of hair depends on the amount of pigment, and increases with age. Red hair contains pigment in the hair cells, but not in the cement substance. The hair turns gray or white (Metchnikoff) through the action of mononuclear phagocytes in absorbing the pigment granules and removing them from the hair.

An over-accumulation of dead epidermal scales is known as scurf or dandruff, and is favored by weakness, poor blood, sluggish circulation, dyspepsia, constipation, fevers, mental strain, or worry. Death results from burns involving one-third or more of the body surface, and is due to destruction of the red blood-cells, with tendency to intravascular coagulation. India ink and cinnabar are used for tattooing.

CONNECTIVE TISSUES.

White fibrous tissue consists chiefly of collagen; elastic tissue, of elastin. The cement substance is a form of mucin. Reticular tissue (mainly collagen) contains the albuminoid reticulin, rich in P. In adipose tissue the protoplasm is replaced largely by fat, the nucleus being forced to the edge of the cell. The limiting membrane of the globules is a kind of elastin. Fat cells contain an orange-yellow pigment, or lipochrome, which is left after the fat disappears in emaciation.

Tendons are about 63 per cent. water. Collagen makes up the white fibers. The ground substance is mucoalbuminous in nature. Extractives (creatin and others) and inorganic salts are likewise present. Lymph-glands consist of a framework of reticulin, with some collagen and elastin. The cells are especially rich in nucleohiston. The general mucoid infiltration in myxedema is due to a degenerative change in the fibrous and connective tissues.

CARTILAGE.

The matrix, capsules, and cancellous substance are composed of collagen or chondrin; the cells, of a globulin. The organic basis of cartilage is a mixture of collagen, insoluble albumin (albumoid), and chondroitin-sulphuric acid, $C_{18}H_{20}NO_4SO_3$; this mixture being termed chondromucoid. Ca salts are gradually deposited in old age. Modern investigations bear out the older view of Garrod that gout is due to retention of sodium urate in the cartilages. The cornea is composed chiefly of collagen and a mucoid substance containing 2 per cent. S.

THE VISCERA.

These consist on the average of about three-fourths water (pancreas, 90 per cent.), and are alkaline in reaction, but become acid after death. Pigment accumulates in the spleen and liver, in malaria, from the destruction of red corpuscles. The spleen-pulp contains considerable purin bodies. Liver iron occurs as the complex ferratin and as albuminate.

Cellular degenerations, says Roger, depend upon three distinct causes: 1. Deficient supply of nutrient materials (starvation, anemia, hemorrhage, deficient oxygenation). 2. Vitiation of the interstitial plasma (cardiopulmonary insufficiency, autotoxemia, infections, As, P). 3. Disturbance or suppression of the functions of the cells (a trophic effect). For obvious reasons, the local frequency of degenerative lesions is proportional to the functional activity of the organs.

Visceral degenerations include fatty, amyloid, fibroid, mucoid, colloid, calcareous, pigmentary, and malignant (of benign tumors). In the cloudy swelling of inflamed organs the cells are filled with an albuminous liquid holding small granules in suspension. In fibroid or glassy degeneration (coagulation necrosis) the cells lose all their histochemic properties; caseous degeneration is a final stage, and calcareous degeneration often accompanies the sclerotic form. The change to fat occurs when oxidation is deficient, as in P, As, and Sb poisoning; alcoholism and yellow atrophy. Liver fat (normally 3 or 4 per cent.) may increase tenfold by degeneration of this organ. Amyloid is a pale, waxy pathologic protein formed during the course of chronic wasting diseases. Mucoid degeneration is manifested by excess of mucin (in small cysts resembling vacuoles). Vitreous colloid consists of NaCl and colloidin, which is colored red by Millon's reagent. The melanin (ocre, rubigin) of pigmentary degeneration (malaria, Addison's disease, melanotic cancer) is identic with normal melanin, and is probably derived from hemoglobin. The lungs are often darkly pigmented (anthracosis) in coal miners. They may show a reddish tinge (siderosis —from oxids) in iron workers. In atheroma of the blood-vessels the yellow spots show fatty and calcareous degeneration. Arcus senilis depends on calcareous deposits in the cornea. Calcareous concretions have been found in all the viscera, and particularly in connection with pulmonary tubercles.

Microchemistry of Degeneration.—In the specimen fixed with OsO_4, the fat appears in small black granules, most abundant about the nucleus of cells. Microscopic deposits of phosphates or carbonates stain deep blue or violet with hematoxylin. Melanin turns black with NH_4HS, or blue with K_4FeCy_6 and dilute HCl.

The fibers of the crystalline lens are very rich in albumins and globulins. Its capsule consists essentially of membranin. Cataract, says Raehlmann, is due to optic inequalities of refraction, owing to dissociation of the albuminous particles with interposition of water.

The peculiar vegetative activity of malignant growths is due to chemic or mechanic stimulation, much in the same way as certain lowly organisms have been excited to multiplication of cells and asexual development of larvæ from their ova (parthenogenesis) by the presence of strychnin or by mechanic agitation. The microbic theory of the origin of cancer represents toxins as the incendiary factors in this cell anarchy.

THE BLOOD.

This vital fluid constitutes 1/30 (fasting, young) to 1/13 part, by weight, of the human body. The liver and the muscles contain each about 1/4 of all the blood. Loss of half the mass of blood in adults may cause death. The greater the amount of blood, the stronger the effects of drugs.

The blood is 795 parts water per 1000, and has normally a sp. gr. of 1.055 to 1.062; higher in men than in women, and reduced proportionately with hemoglobin reduction. In cyanotic states it may reach 1.080. Over-concentration of the blood favors coma. The electric conductivity of the blood varies with the concentration of inorganic salts.

Experiment.—Determine sp. gr. of blood by making a mixture of benzol with chloroform in such proportions as to be somewhat lighter than blood. Let a drop of blood from the end of the finger fall into the liquid, and when it has sunk add chloroform drop by drop, with stirring, until the drop of blood floats midway in the liquid. Then filter out the blood and find sp. gr. of mixture with hydrometer.

Blood is saline because of alkaline chlorids, which keep the globulins in solution, prevent disintegration of the corpuscles, and aid osmosis. The alkalinity necessary for proper oxidation is maintained by Na_2HPO_4 and especially Na_2CO_3, which is associated with serum-albumin, the combination being dissociated by CO_2 with formation of $NaHCO_3$.

Experiment.—Prove alkalinity of blood by placing a drop of red litmus solution on a porous porcelain plate. When dry leave a drop of blood on the spot for a minute, then wash off with water.

The alkalinity of the blood can be estimated by mixing 5 c.c. of fresh blood with 45 or 50 c.c. of 0.25 per cent. $(NH_4)_2C_2O_4$ solution (prevents coagulation), titrating the mixture with

$N/_{25}$ $H_2C_4H_4O_6$ solution, using as an indicator lacmoid paper soaked in concentrated $MgSO_4$ solution.

The normal alkalinity is proportional to the red cells, and is said to correspond to about 300 mg. NaHO in 100 c.c. The normal alkalinity is decreased (down to 1/7 normal, with coincident increase of NH_3 eliminated) by the production of sulphuric, phosphoric, sarcolactic, and the volatile fatty acids in the rapid protein catabolism of fevers, and in uremia, Bright's disease (hydremia), rheumatism, anemia, cancer, diabetes, and by great muscular exertion. Alkalinity is increased by persistent vomiting. It is rapidly diminished after the blood is shed. The alkalinity of blood is much diminished at high altitudes, owing perhaps to lessened O-pressure. It is little, if any, altered in gouty conditions. Alkalinity is much decreased (by lactic acid) in poisoning by CO, As_2O_3, strychnin or amyl nitrite. The blood may show an acid reaction in diabetic coma and in some cases of cholera. Strictly speaking, blood is neutral, since it contains no more HO ions than water. Its alkaline reaction to litmus depends on the Na ions present.

The opacity of blood is due to the suspended blood-corpuscles, the red variety of which gives color mainly to the blood, though serum also contains a coloring matter termed lutein. Non-oxygenated blood is dichroic (dark-red by transmitted light; green by reflected light).

Experiment.—Gently shake some fresh blood (diluted 1 to 5) in a test-tube with ether. The cells are dissolved, and the liquid becomes transparent or laky.

The peculiar and specific odor of blood depends chiefly on the presence of volatile fatty acids, and is rendered more distinct by the addition of H_2SO_4.

With the hematocrit the red corpuscles make up nearly half, the white cells 1/40, and the plasma a little more than half the height of the column. The number of leucocytes (normally 3000 to 10,000) is increased (leucocytosis) in leukemia and in most inflammations, particularly when ending in suppuration (relative excess of polynuclear neutrophiles). Digestive leucocytosis (three or four hours after meals) is due probably to stimulation by products of protein metabolism. The white cells per cu. mm. are increased by bleeding, lactation, or quinin; diminished by large doses of Hg. Leucocytosis is absent in malaria, measles, typhoid, pure tuberculous infections, and early stages of grip. The albuminous granules of leucocytes have affinity for acid (oxyphilic), basic (basophilic), and neutral (neutrophilic) dyes respectively.

The erythrocytes (normally 4½ to 5 million per cu. mm.) are diminished in anemias (with proportionate oligochromemia in simple secondary—lower than coloring matter in pernicious). In chlorosis there is great hemoglobin reduction (low color index) with but slight lessening of corpuscles. There is physiologic excess (polycythemia) of red cells, at high altitudes, due to cardiac dilatation. In pulmonary stenosis the blood-count has reached 9½ millions, and Hb 160 per cent.

Hydremia is particularly noticeable after hemorrhages and in amyloid nephritis, and is accompanied by absolute hypalbuminosis. Increase of fibrin (hyperinosis) has been noted in pneumonia, erysipelas, and acute rheumatism. The opposite condition, hypinosis, is said to occur in malaria and pernicious anemia. In general, the percentage of proteids varies inversely with the amount of water in the blood. Sugar and lactic acid increase in the blood whenever tissue oxidation is imperfect.

The sugar in the blood is increased up to 9 per mille in diabetes, and is also considerably increased in carcinoma. It may be estimated in the usual way after removing the proteins by boiling with Na_2SO_4. Acetone is found in the blood in fevers and diabetes. The glycogen reaction is pronounced in diabetes, leukemia, severe anemias, and suppuration. It is, in general, a sign that the patient is very sick. To test for glycogen a drop of blood is spread between cover slips and allowed to dry, then treated with a solution containing 1 gm. I and 3 gm. KI in 100 gm. of concentrated mucilage. The glycogen appears as brown granules free or in the leucocytes. Leukemic blood (2 or 3 drops), mixed with enough water so that no color remains, gives a deep blue color on adding tinct. guaiac (without H_2O_2); ordinary blood does not.

The composition of the blood may be represented somewhat graphically by the outline on following page:—

An increase of fat (lipemia) is noted after the ingestion of large amounts of fatty foods and in obesity, chronic alcoholism, hepatic disease, and after injury to the long bones. Lipacidemia has been observed in fevers, leukemia, and diabetes.

Cholemia is met with in cases of obstinate jaundice, excessive secretion of bile, and destruction of red blood-corpuscles. The serum shows a yellowish tint. Urea is much increased in the blood in nephritis and cholera. From 3 to 6 mg. of uric acid per 100 c.c. of blood obtains in gout, no matter what the diet. The smallest trace, if any, is found in normal blood on a purin-free diet.

Other pathologic extractives occasionally encountered are xanthin, hypoxanthin, paraxanthin, guanin, adenin, leucin, tyrosin, lactic acid, and beta-oxybutyric acid.

The coagulation of blood (normally in 4 to 7 minutes) is believed to be due first to the union of Ca salts ($CaCl_2$ especially) through the agency of the activator (thrombokinase) with the zymogen prothrombin (from plaques and leucocytes of shed blood), forming fibrin ferment (thrombin).

This, in turn, combines with fibrinogen to form a network

COMPOSITION OF THE BLOOD.

- Plasma (52 per cent.)
  - Serum
    - Water (90 per cent.).
    - Serum-albumin (4.5 per cent.).
    - Serum-globulin (3.1 per cent.): Euglobulin (a true globulin). Pseudoglobulin.
    - Dextrose (0.1 to 0.15 per cent).
    - Salts=NaCl (0.65 per cent.), $CaCl_2$, KCl, $MgCl_2$, $Mg_3(PO_4)_2$, $CaHPO_4$, $CaSO_4$, carbonates.
    - Fat (0.2 to 1.2 per cent.).
    - Ferments: diastatic, glycolytic, steatolytic, proteolytic.
    - Extractives=urea (0.016 per cent.), uric acid, creatin, sarcolactic acid, etc.
    - Gases
      - O=22 volumes per cent. in arterial, 12 per cent. in venous.
      - CO_2=40 volumes per cent. in arterial, 48 per cent. in venous.
      - N=1 or 2 volumes per cent. in arterial and venous.
  - Fibrinogen (0.5 per cent.).

clot

- Corpuscles (48 per cent.)
  - Red
    - Water (58 per cent.).
    - Hemoglobin (combined with lecithin; about 90 per cent. of dry corpuscle, 13 to 14 per cent. of wet corpuscle).
  - Stroma (40 per cent.)
    - Lecithin.
    - Cholesterin (0.045 to 0.12 per cent.)
    - Salts=KCl and K_2HPO_4.
  - White (1 to 350 of red)
    - Water, 88.5 per cent.
    - Nucleo-histon (3 per cent. P).
    - Globulin.
    - Glycogen.
    - Lecithin.
    - Cholesterin.
    - Fatty granules.
    - Albumose.
    - K_2HPO_4.
  - Blood-plates=nucleoproteids—nuclear derivatives.

of fibrin threads (and a trace of soluble globulin), which enmesh and contract upon the corpuscles, making the clot and setting free the serum. The so-called buffy coat is made up of leucocytes. Freshly drawn blood is readily defibrinated by whipping quickly with a stick or a fork. The elastic strings of fibrin thus collected when thoroughly washed resemble boiled white of egg. For the tests given below defibrinated blood should be employed.

To separate blood-serum from the clot the blood should be received in a rather wide vessel, and as soon as it clots be placed in an ice-chest for thirty-six to forty-eight hours or longer, until the serum is clear and straw-colored. The corpuscles can be pptd. from defibrinated blood by adding a $\frac{1}{10}$ saturated aqueous solution of NaCl to $\frac{1}{10}$ its volume of the blood, pouring the mixture into a shallow dish, and after settling decanting.

Coagulation can be prevented by adding to the freshly drawn blood ammonium oxalate (0.1 per cent.) or sodium citrate (1 per cent.). Clotting is favored by heat and dilution with water.

The blood is deficient in Ca salts in hemophilia. It does not coagulate in asphyxia (excess of CO_2), nor along with oil. A "buffy coat" of white cells appears during very slow clotting.

The most important constituent of the blood is the coloring matter hemoglobin, which constitutes over 90 per cent. of the organic matter of the red corpuscles. It is composed of globin (contains all the S), histon and hematin, and in the dry state contains 0.42 per cent. of Fe. It carries O or CO_2 (molecule for molecule) from the lungs to the tissues, in a loose combination known as oxyhemoglobin. Hemoglobin, or reduced hemoglobin, is the coloring matter of venous blood, and oxyhemoglobin that of arterial blood. Hemoglobin crystallizes with difficulty in purple crystals; oxyhemoglobin more readily in long, bright-reddish prisms. H_2O (ether, chloroform, etc.) remove the coloring matter from the corpuscles and thus render blood laky (dark crimson; transparent) by hemolysis. On long exposure to air oxyhemoglobin stains isomerize into the more stable brown acid methemoglobin, which is found also at times in cystic fluids and transudations. Oxidizing agents, such as H_2O_2, likewise convert oxyhemoglobin into methemoglobin. The latter crystallizes in red-brown needles or plates, and yields a brown, aqueous solution, turning red on rendering alkaline. Oxyhemoglobin is dextrogyrous. The O-capacity of Hb is 1.34 c.c. per gram. Hb is found outside of the blood in striped and unstriped muscle tissue.

On heating with acids or alkalies oxyhemoglobin decomposes into globulin and the Fe pigment hematin; reduced hemoglobin into hemochrom and a globulin. Hematin is dark-brown or blue-black, and amorphous. The dark color of "coffee-ground" vomit in gastric cancer is due to hematin, formed by the action of HCl on blood. Hematin combines with nascent HCl to form hematin hydrochlorate, or hemin: a crystalline substance of vital importance in the identification of blood-stains.

Experiment to Identify a Blood-stain on a Piece of Cloth or Wood.—Add to a few of the fibers or scrapings on a glass slide a drop of 1 per cent. NaCl solution, and warm very gently till nearly dry. Then add at once a drop or two of glacial acetic acid, put on a cover-glass, and warm again gently till nearly dry. Allow to cool and examine under microscope for small, dark-red, rhombic (rarely whetstone) hemin crystals. These Teichmann crystals are insoluble in water, but dissolve in alkalies, with formation of hematin. Their formula is $C_{32}H_{34}FeN_4O_6.HCl$. Fat and rust interfere with the hemin test.

Hematoporphyrin is an iron-free derivative of hematin, prepared by the action of strong acids, and isomeric with bilirubin. It is wine-red in color, and may be noted in the gastro-intestinal contents after mineral-acid poisoning.

Experiment.—To 10 c.c. of H_2SO_4 in a test-tube add 4 or 5 drops of blood, shaking thoroughly with each addition. Note the color of hematoporphyrin.

Hematoidin is a hemoglobin derivative similar to, if not identic with, bilirubin. It appears in orange- or ruby- colored, amorphous, or crystalline particles in old extravasations and in the sputum, urine, and feces after hemorrhages.

CO hemoglobin is a compound similar to oxyhemoglobin, but is more stable; hence the grave character of CO poisoning, since O cannot displace CO and be carried to the tissues.

Experiment.—Pass a current of illuminating gas for a few minutes through some diluted blood (1 to 50). Note change of color to cherry red. Prove that CO hemoglobin is a stronger combination than oxyhemoglobin by treating dilute solutions of each with twice as much strong NaHO solution (pure blood becomes brownish, with a green tinge); with H_2S (pure blood turns green); and with a drop each of dilute $HC_2H_3O_2$ and K_4FeCy_6 solution (brownish ppt. with pure blood), in all of which tests the CO hemoglobin solution remains unchanged in color. Nitric oxid hemoglobin gives bands similar (paler and less sharply defined) to CO hemoglobin, and like the latter does not disappear on adding a reducing agent. The green tint of the abdomen in cadavers is generally due to the action of intestinal gases (H_2S) on the blood coloring matter diffused in the tissues.

FeS

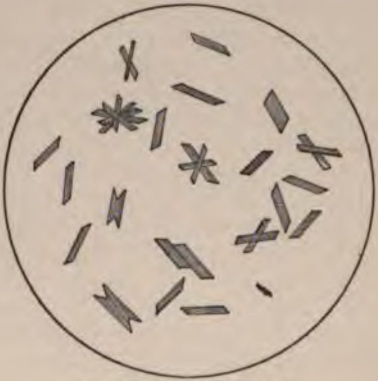


Fig. 58.—Hemin Crystals.

The spectroscope furnishes the most delicate evidence of the presence of blood in solution, readily showing 1 part in 10,000.

Spectroscopic Tests.—Dilute defibrinated blood with 200 parts of water, and suspend some of the fluid in a narrow test-tube about an inch before the slit of the instrument, with a fish-tail burner two inches farther away. 1. Compare the position of the oxyhemoglobin with that of the Na lines. 2. Reduce the oxyhemoglobin by adding a drop or two of Stokes's solution (2 $FeSO_4$ and 3 $H_2C_4H_4O_6$ dissolved in H_2O and rendered alkaline with NH_4HO), and note position of single band. Shaking restores the two characteristic oxyhemoglobin bands. 3. To the reduced hemoglobin add a few drops of strong NaHO solution, forming hemochromogen, and compare two bands with those of oxyhemoglobin. 4. Tests can be made for the spectra of methemoglobin (warm dilute blood with a few crystals of $KClO_3$), alkaline hematin (heat blood with

NaHO till color becomes a greenish brown), CO hemoglobin (blood diluted 1 to 50), and hematoporphyrin. The one band in the orange is characteristic of methemoglobin.

It is possible that hemoglobin, like chlorophyl, acts as a dehydrating agent, forming glycogen from glucose. Blood leaving a resting gland is dark and venous; that from an active gland is brighter, owing to CO_2 being given off in the secretion. There is no deficiency of O in the blood in gout and diabetes. By some blood is thought to contain a ferment (oxydase) which converts Hb into oxyhemoglobin, and another (katalase) that liberates O to the tissues.

According to Sajous, the adrenals secrete a chromogen—a colloid, hyaline fluid—which is mixed with the circulating plasma in the inferior vena cava. When the venous blood reaches the pulmonary alveoli, the marked affinity of the adrenalized plasma for oxygen causes it to absorb this gas from the alveolar air, with consequent forcible expulsion of CO_2 from the blood. The adrenoxin, or oxidizing substance, formed by this union of O and adrenal secretion, is only partly absorbed by the hemoglobin of the corpuscles, the balance remaining in the plasma. This substance is the reagent to which the oxidation processes that occur in the blood-stream are due.

The cells of chorionic villi serve as an osmotic membrane through which O and nutritive lymph pass from the mother's blood to that of the fetus, while the fetal blood gives off CO_2 and probably urea.

Plumage pigments consist of lipochromoids and melanoids closely related to the pigments of fishes and reptiles. The blood of most insects is green (from chlorophyl) and darkens on exposure to the air.

Specific Test for Human Blood.—It is practically impossible to distinguish by the ordinary chemic, microscopic or spectroscopic tests between the blood of man and that of some other mammals. The specific test of Bordet consists in administering to rabbits every other day several subcutaneous injections of 10 c.c. defibrinated human blood (obtained by wet-cupping, leeching or placental expression), the animals being bled to death six days after the last dose, and their blood placed in a vessel on ice to separate the serum. Five-tenths c.c. of this rabbit-serum is added to the suspected blood or stain, diluted about 100 times with decinormal salt solution, when, if the reaction is positive, a distinct cloudy ppt. forms rapidly. The test is best done at 37° C. The reaction is negative with the blood of other animals, except the monkey, which yields a delayed and incomplete reaction. The rabbit-serum should be rather fresh, as it loses its specificity after about four weeks. The reaction may be secured in dilutions of the test serum 1: 20,000 or of the blood tested 1: 1000. Only albumin precipitants interfere with this test. In the Bordet test for human blood there should be distinct cloudiness within thirty minutes, and a ppt. within two hours. Control tests from different domestic animals should always be made.

SECRETIONS.

These are the special products of particular glands. They are mostly liquid or semiliquid, and are composed of water, inorganic salts, and organic compounds. True secretions are formed from the blood, but do not pre-exist in the blood, and are of service to the organism. They may be classified as selective filtrates (tears, sweat, urine), products of new principles (saliva, gastric juice, bile), glandular desquamations (milk, mucin, sebum), and morphologic secretions (specialized cells, as semen). As the blood is alkaline, so all the secretions (except gastric juice and mucus) are alkaline and of lower sp. gr. than the blood. Psychic emotions affect both the quantity and quality of secretions, and they are generally diminished in fevers.

The digestive fluids constitute the most important class of secretions. They all have a somewhat similar composition (phosphates, chlorids, carbonates, sulphates of Na, K, Ca, and Mg) except in regard to the ferments which they contain. These exist in the glands as zymogens, needing to combine with dilute acids or alkalies to form the full enzyme. The quantity of secretions varies normally with the amount of liquids drunk. The secretion of the gastric and pancreatic juices depends on specific hormones; the gastric hormone being secreted by the pyloric portion.

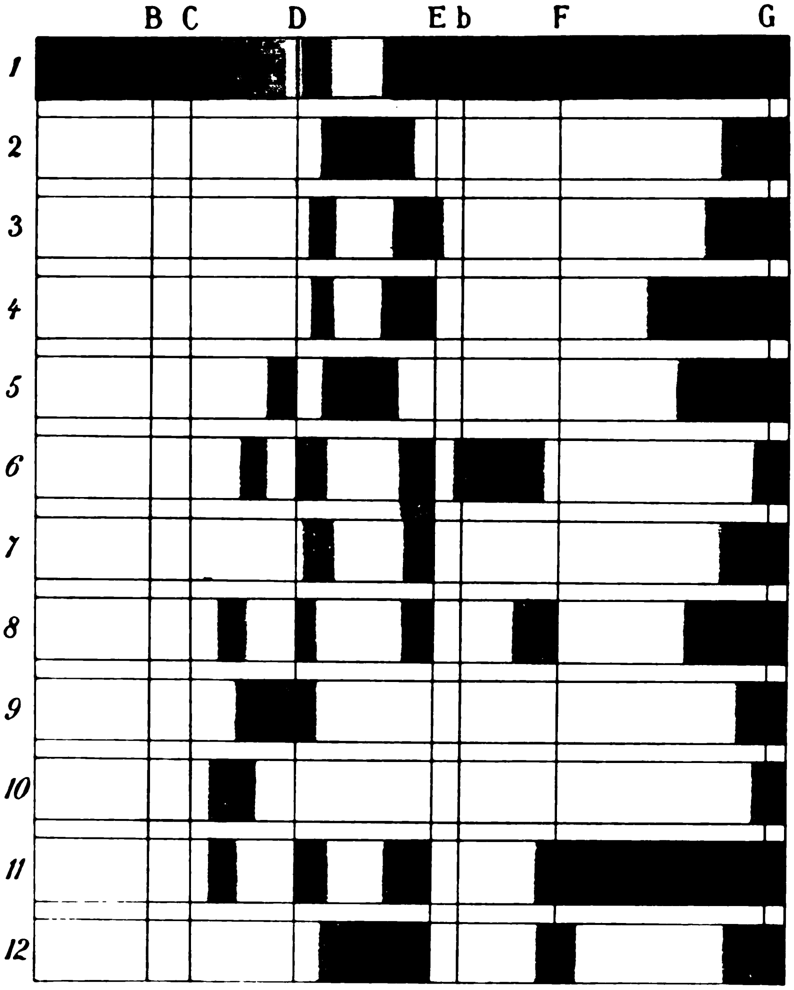
The secretin of the intestinal mucous membrane is called out by HCl, is heat-proof (not a proteid), and, passing through the blood to the pancreas and liver, excites the external secretions of these organs. The flow of saliva and gastric juice depends largely upon the present appetite, while the HCl of the gastric juice is the prime stimulant of pancreatic secretion, thus neutralizing itself as the acid chyme is propelled at intervals through the pylorus. The quantity of secretion bears a close relation to the kind and amount of food taken. Thus, the gastric or pancreatic juice poured out on bread (starch and protein) has the greatest digestive power; that on milk, the lowest. Food preservatives (Wiley) and large amounts of alcohol may inhibit or restrict digestion.

The table on opposite page shows the chief points in the chemistry of these secretions.

SALIVA.

Normal saliva is opalescent, odorless, frothy, slightly cloudy, and faintly alkaline to litmus—acid to phenolphthalein, owing to CO_2. The quantity of saliva is diminished by atropin, in fevers, diabetes, nephritis, fright, and severe diarrheas; increased (salivation, ptyalism) by Hg, KI, pilocarpin, acids (saliva rich in proteids), and by mastication, ether, dry foods, pregnancy, and local inflammatory conditions. It has a bad smell in scurvy,

PLATE VI.



ABSORPTION-SPECTRA.

(Rockwood.)

1. Oxyhemoglobin.
2. Hemoglobin.
3. CO hemoglobin and CO hemochromogen.
4. Methemoglobin, alkaline.
5. Hematoporphyrin, acid.
6. Hematoporphyrin, alkaline.
7. Hemochromogen, alkaline.
8. Hematin, acid.
9. Hematin, alkaline.
10. Sulphur methemoglobin.
11. Methemoglobin, neutral or faintly acid.
12. Pettenkofer's test for biliary acids.

SECRETION.	AVERAGE DAILY QUANTITY.	SPECIFIC GRAVITY.	FERMENTS.	OTHER CONSTITUENTS.
Saliva.	800 to 1500 c.c.	1.002 to 1.008	Ptyalin (0.1 per cent.), amylolytic (on boiled starch). Maltase (glycolytic). Activator to gastric juice.	Mucin (1.4 per cent.). Potassium sulphocyanate (0.1 per cent.). Epithelial and salivary corpuscles. Inorganic salts (2 p. m.) = chlorids, carbonates, nitrites, sulphates, phosphates of Na, K, Ca, and Mg. H_2O_2. Gases (CO_2), 20 per cent. volume.
Gastric juice.	2000 to 3000 c.c.	1.002 to 1.010	Pepsin (1.75 per cent.), proteolytic. Rennin (pexin, lab-ferment), milk-curdling ferment. A glycolytic ferment. A lipolytic ferment. Pseudopepsin; proteolytic. Chymase, synergistic to pancreatic ferments.	Hydrochloric acid (free, 0.1 to 0.2 per cent. Organic acids = lactic, acetic, butyric (below 0.1 per cent.). Acid phosphates (0.12 per cent.) of Mg, Ca, and Fe. Alkaline chlorids (0.2 per cent.). Mucin.
Pancreatic juice.	500 to 800 c.c.	1.008	Trypsin, proteolytic. Amylopsin (maltase, lactase, invertase), amylolytic. Steapsin, fat-cleaving. Rennin, milk-curdling.	Sodium carbonate (0.3 per cent.). Fats and soap. Albumin. Leucin and tyrosin.
Bile.	500 to 800 c.c.	1.010 to 1.033	Pialyn, fat-cleaving. A diastatic ferment. A proteolytic ferment.	Bile-salts (7.5 per cent.) and pigments. Fat (0.9 per cent.) and soap. Cholesterin (0.25 per cent.), lecithin, and urea. Mucus and albumin. Sodium carbonate (0.25 to 0.5 per cent.). Salts of Ca, Mg, Fe, and Cu.
Intestinal juice.	100 to 300 c.c.	1.011	Invertase, glycolytic. Maltase, glycolytic. Lactase (infants). Erepsin, proteolytic. Lipolytic ferment.	Salts (NaCl; Na_2CO_3), 0.5 per cent. Mucin and albumins (1.5 per cent.).

gingivitis, and mercurial salivation. It is acid (lactic acid) in the morning before breakfast and sometimes after much talking, and may be constantly acid from oral fermentation (lactic acid), Hg salivation, and in rheumatism and diabetes, fevers, and indigestion; intensely alkaline in ulcerative stomatitis. When it is strongly acid, considerable galvanic action may take place with dental fillings or metal plates. Albumin is present in ptyalism; urea, in nephritis; uric acid, in goutiness. The secretion of the parotid gland is most fluid; that of the sublingual and submaxillary more slimy. There is only a trace of ptyalin in saliva for some months after birth.

An acid condition of the saliva favors pyorrhea alveolaris and the rapid formation of soft, light-colored tartar. A bad breath from a filthy mouth or decayed teeth is due to putrefactive germs and gas-forming bacteria. The odor is very stale and foul, even slightly cadaveric, in patients who are extremely ill. It is sweet and sickening, from decomposing pus, in advanced tuberculosis. Tobacco favors bacterial growth. Aside from the digestive action of mixed saliva, it serves as a lubricating and washing-out fluid.

Experiment.—Find by titration the acidity of saliva estimated as H_2CO_3 (more than in venous blood).

Experiment.—Test for mucin by adding to clear saliva acetic acid drop by drop, and note ppt. of mucin in white strings or flakes.

Experiment.—Test for sulphocyanate in saliva by filtering a small quantity and adding a mere trace of HCl, a drop of very dilute $FeCl_3$. The red color disappears on adding $HgCl_2$. This test is sometimes negative. Thiocyanate is an index of proteïd metabolism, and is therefore diminished in cachexias. It is marked in amount in smokers.

Salivary calculi depend on inflammatory conditions, and are sometimes deposited in the salivary ducts. They are composed of $CaCO_3$ and $Ca_3(PO_4)_2$ (cemented with organic matter), which salts are normally held in solution by CO_2. Salivary corpuscles are swollen leucocytes.

Test for Hg in Saliva.—Collect 100 c.c. or more of saliva, acidulate with HCl, digest on water-bath for two hours, adding now and then a drop of HNO_3. Filter and concentrate to 10 c.c. Take a little of this in a test-tube, add a small fragment of bright Cu, and boil. If Hg is present, it will form a gray coating on the Cu, driven off by heating.

GASTRIC JUICE.

This is a thin, pale-yellow liquid containing 0.5 per cent. of solids. It is often mixed, however, as usually obtained, with viscid mucus from the throat. The normally frankly acid reaction of gastric juice is due chiefly to the free HCl, partly to the acid phosphates. The HCl is derived from common salt by the mass action of CO_2 or by reaction with the sodium bicarbonate of the blood:—

$$NaCl + NaHCO_3 = Na_2CO_3 + HCl$$

From the viewpoint of physic chemistry, HCl is formed in the stomach owing to the permeability of the walls of this organ for Na ions (passing out) and H ions (passing in), and its impermeability to Cl ions. HCl is furnished by the cells (parietal, oxyntic, delomorphous) in the middle region of the stomach; pepsin and chymosin, by the adelomorphous cells toward the pyloric end.

The secretion should cease normally after digestion is complete. Water, meat extracts, raw beef, and the products of protein digestion (peptons) are reliable excitants of gastric secretion, which fats inhibit both qualitatively and quantitatively. Starch and egg-albumin are inactive in this respect; milk and gelatin have but slight effect as stimuli.

Free HCl ranges from 0.1 to 0.2 per cent. in the gastric juice. The amount increases from the beginning of digestion. It combines loosely with protein molecules. Fluctuating amounts of free HCl point to a neurosis. The rule is, that the more rapid the secretion of gastric juice, the more acid it is, and the first juice has the strongest digestive power. The total acidity is highest with flesh and lowest with bread foods.

Moderate amounts are often found in the fasting stomach of healthy subjects. This acid appears to prevent the further secretion of gastric juice when considerable has accumulated; other acids have not such an action. It converts pepsinogen and rennin zymogen into the active ferments, but its chief function is antiseptic. The offensive odor (absence of HCl) of the siphoned gastric contents is of great diagnostic value in carcinoma (Lenhartz), and may be noted in the absence of vomiting and a palpable tumor.

HCl is deficient (hypochlorhydria) in most cases of ordinary functional dyspepsia, and in fevers, chlorosis (50 per cent.), chronic alcoholism, and renal, hepatic, cardiac, hemic and pulmonary diseases. It is greatly diminished or absent in cancer of the stomach (ulcerating growths yield an alkaline juice, neutralizing HCl), liver, and uterus, pernicious anemia and chronic atrophic gastritis. Hyperchlorhydria is usually a neurosis (often with hypersecretion—gastrosuccorrhea), and is a significant sign of gastric ulcer. The excessive use of tobacco and condiments, small amounts of alcohol or creosote, and the delay of food in the stomach, are said to increase the amount of HCl.

Free HCl is an effective germicide, though not destructive to spores. Bacterial fermentation, of carbohydrates mostly, with production of organic acids (lactic, acetic, and butyric) and alcohol, is therefore to be expected with hypochlorhydria. Hyperacidity may be due either to excess of HCl or of organic acids. Mineral acids given before meals decrease the secretion of HCl; given after, they prevent the formation of organic acids. Alkalies before meals favor the secretion of HCl; given after meals they relieve acid eructations from any cause, but only for the time being.

The fatty acids and simple gases (H, CO_2, and CH_4) are also found in the stomach-contents in some cases of hyperchlorhydria with retention; these cases are, however, not accompanied by putrefactive changes. Frequent feedings also interfere with gastric self-disinfection. Lactic acid is not found in more than traces (never normally above 0.3 per mille, except from milk) normally after digestion has progressed for more than a half-hour, owing to the inhibiting action of HCl (0.07 per cent.), or until the entire food mass has been permeated by the mineral acid. In the absence of HCl, lactic acid may reach 0.4 per cent. It is especially abundant in late cancer.

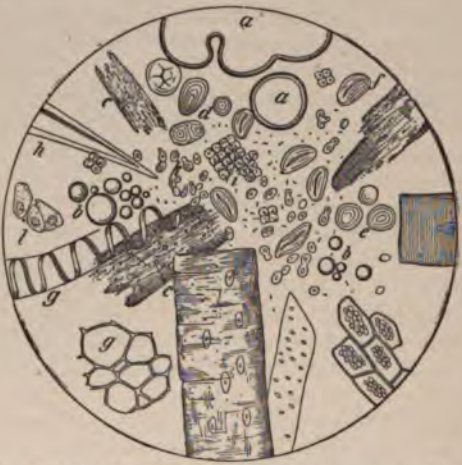


Fig. 59.—Gastric Contents. Collective Microscopic Picture. × 350. (*Lenhartz.*) *a*, Air-bubble. *b*, Oil-droplet. *c*, Muscle-fiber, nearly digested. *d*, Potato starch. *e*, Swollen rye starch. *f*, Leguminous starch. *g*, Various vegetable cells. *h*, Vegetable hair. *i*, Sarcina. *k*, Yeast fungi. *l*, Gastric gland-cells.

The succus pyloricus is said to be alkaline, as is the reaction of the slimy secretion of the stomach in a state of rest. Fermentation is best prevented by restriction of carbohydrates and by the administration of HCl in sufficient doses after meals. The stomach-contents generally contain a little mucus, which is greatly increased in the acute and the mucous forms of subacute and chronic gastritis, and tends to neutralize free HCl. Acetone, alcohol, and aldehyd may be present from fermentation. The stomach contains more bacteria per cu. mm. than the first part of the duodenum or the large bowel.

Experiment.—Make NaH_2PO_4 by adding H_3PO_4 gradually to Na_2HPO_4 solution till it does not ppt. $BaCl_2$. Show with litmus-paper that the acid phosphate thus formed is not neutralized by $CaCO_3$, whereas free and loosely bound HCl are.

Experiment.—Make a 0.2 per cent. solution of HCl. Show that it turns methyl-violet (lilac to blue streaks at margin on warming conc. alcoholic solution with an equal amount of chyme filtrate) solution blue, congo red blue (sulphonic acid), and tropeolin 00 from yellow to red.

Experiment.—Test the HCl solution in a casserole by adding a few drops of a 5 per cent. solution each of cane-sugar and resorcin. On warming gently a red line appears at the border.

BILE.

Bile is a mixture of hepatic cell-secretion and of mucus derived from the gall-bladder and ducts, and is both a secretion and an excretion, being passed into the intestine during digestion only. Fat, meat extracts and the digestion products of ovalbumin stimulate the flow of bile. Bile is normally alkaline (carbonates and phosphates), soon becoming acid on exposure to the air, and later again alkaline (NH_3 and trimethylamin). It is thick, viscid, and very bitter, and varies in color from light-yellow to greenish-blue. It contains from 7 to 18 per cent. of solids (1 to 4 per cent. from a fistula).

The chief bile-salts proper are the glycocholate and taurocholate of sodium, the former occurring in four times the quantity of the latter. They are dextrorotatory, and are pptd. as fine needles from alcoholic solutions by addition of ether. They are products of proteid metabolism in the liver.

The office of these salts in digestion is to ppt. peptons in the small intestine, thus aiding their absorption. They also keep the fatty acids (forming soluble neutral and acid salts) and lecithin and cholesterin in solution. Bile-salts in the blood cause the slow pulse of jaundice.

Normal bile contains two pigments: bilirubin, or bilifulvin ($C_{16}H_{18}N_2O_3$) (reddish yellow); and biliverdin ($C_{16}H_{18}N_2O_4$) (green). The former is derived from hematin, and yields the latter by oxidation; on putrefactive reduction hydrobilirubin (stercobilin, urobilin) results from the O-affinity of the colon and lactic acid bacilli. Biliverdin is insoluble in $CHCl_3$, which dissolves bilirubin. Bile-pigment contains no Fe, which has been split off in the liver.

Altered bile and bile-stones contain other pigments, such as bilifuscin (brown), biliprasin (greenish black), bilicyanin (bluish), and choletelin (yellow to brown). Pigment is often low in tuberculosis; high in congestive conditions, particularly when due to heart disease. Hydrobilirubinemia is the condition in mild cases of icterus; bilirubinemia, in severe. Bilirubin is held in solution in bile by sodium glycocholate. When there is reduced formation of bile-acids, it accumulates in the liver, is absorbed by the lymphatics, and produces "liver spots."

Bile-salts are formed only in the liver. Bile-pigments are formed normally in the liver, but also abnormally from the breaking down of red corpuscles and extravasations in other parts of the body. Thus, there are two kinds of jaundice:

hepatogenous (usually obstructive, with lymph absorption) and hematogenous. In both, however, the liver is concerned. Cholemia leads to destruction of red corpuscles and circulatory disturbances. A diminished biliary flow into the intestine favors constipation and putrefaction. Bile itself quickly becomes putrid on standing. The bile is a natural purgative, through its stimulating action on the intestinal muscular layer. Deficiency of bile favors putrefaction by the unchanged fat enveloping particles of albumin, so preventing their digestion.

The bile has but little chemic action on food. Its digestive importance depends on its accentuating influence on the pancreatic ferments, whose action is doubled or trebled. The total amount of bile, as well as the proportion of solids, is generally diminished in fevers. A little greenish bile is commonly present in vomit when this is frequent or severe. The presence of bile in the stomach-contents drawn with a tube is suspicious of stenosis of the small intestine. The bile of one day, injected into the veins, would be sufficiently toxic to kill three men.

Biliary cholesterin is probably an accumulation residue of the hydrolysis of carbohydrates by the epithelium of the gall-bladder and bile passages. When in excess of the solvent action (diminished in cholecystitis) of the bile salts it crystallizes out, forming gall-stones, their formation being favored by catarrhal conditions, stagnation of bile, and the presence of attenuated bacteria (typhoid or colon bacilli).

Pure cholesterin stones are white, soft, greasy and friable, and float on water. Gall-stones usually have a nucleus of epithelium or bacteria, and are cemented with mucus or lime soaps. Pigment stones (calcium bilirubinate) often contain copper and iron, and sink in water. "Onion stones" consist of alternate layers of cholesterin and calcium bilirubinate, the formation of the latter being favored by catarrh of the gall-bladder (acid mucin and Ca in mucus). The average composition of gall-stones is 70 to 80 per cent. cholesterin, with pigments, but they are sometimes made up mainly of pigments or $CaCO_3$.

Gall-stone colic and soreness are most frequent in stout, elderly women, by reason of their sedentary ways, proneness to a diet of sweets and starches, and constipated habit. Gall-bladder attacks usually occur at night, because of distention of the sac with bile, owing to the longer interval between meals.

Gall-stones are commonly multiple and have a tabloid or polygonal form, the faceting being due to friction in the bile-bladder. Cholesterin is insoluble in water, but is readily dissolved *in vitro* by ether, chloroform and fixed or volatile oils. The benefit derived at times from the use of these reagents as remedies for cholelithiasis, however, probably depends on their relaxant and soothing action rather than on their solvent properties. Olive-oil causes the passage of pseudocalculi composed of lime soaps.

Experiment.—To some fresh ox-bile in a test-tube add twice as much water. Filter, if not clear, and add acetic acid. Note slight ppt. of mucin (more in human bile).

Experiment. Test for Bile-acids.—Add to a few c.c. of well-diluted bile two-thirds its own volume of strong H_2SO_4, letting the acid run slowly down the side of the tube so as not to mix, and keeping the temperature below 70° C. Then add 2 or 3 drops of a 10 per cent. cane-sugar solution, and shake gently. A pink, red, or violet color develops, with a pink foam. The reaction depends on the formation of furfurol. Albumin or morphin gives a similar color-reaction.

Experiment.—Pulverize a small gall-stone and dissolve in a mixture of warm alcohol and ether. Decant into an evaporating dish and allow to evaporate spontaneously. Note the crystals under the microscope: thin, transparent plates with a notched corner. These show a beautiful play of colors when treated with H_2SO_4 and an I solution.

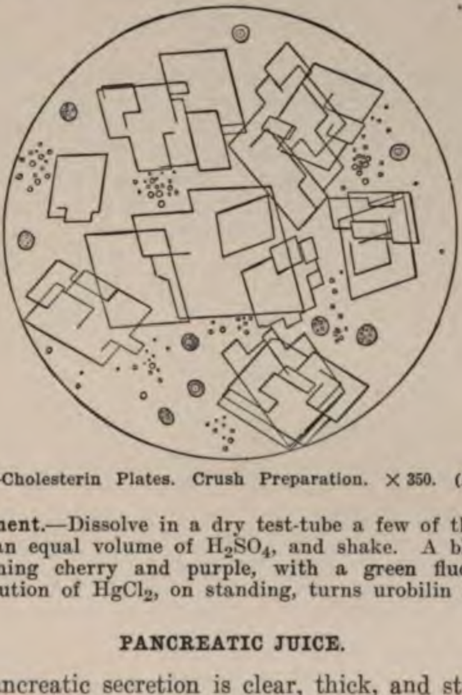


Fig. 60.—Cholesterin Plates. Crush Preparation. × 350. (*Lenhartz.*)

Experiment.—Dissolve in a dry test-tube a few of the crystals in $CHCl_3$, add an equal volume of H_2SO_4, and shake. A blood-red color appears, turning cherry and purple, with a green fluorescence. A saturated solution of $HgCl_2$, on standing, turns urobilin red, bilirubin green.

PANCREATIC JUICE.

The pancreatic secretion is clear, thick, and strongly alkaline, and contains about 10 per cent. of solid constituents: two-thirds organic, one-third inorganic. The alkalinity is due chiefly to Na_2CO_3. The HCl of gastric juice is the prime stimulant of pancreatic secretion, thus neutralizing itself as the acid chyme is propelled at intervals through the pylorus; alkalies depress this secretion. Acids (Bayliss and Starling) act as secretory excitants (pancreatic juice and bile) indirectly, by uniting with "prosecretin" of the duodenal and upper jejunal mucous membrane, forming the substance "secretin" (not destroyed by boiling), which is carried to the pancreas in the blood-stream. The stronger the acid the more powerful its effect on pancreatic secretion, and hyperchlorhydria may sometimes represent an effort of Nature to stimulate a sluggish pancreas or liver. The specific enzyme "chymase" in the gastric juice also accelerates the action of the pancreatic ferments. Spices have no effect on pancreatic secretion; they excite a free flow of protective mucus in the stomach. Pancreatic juice begins to flow two or three minutes after the application of the acid or other exciting agency. Both the bile and the pancreatic juice arrest the destructive action of pepsin in the duodenum. Fat emulsified in the intestine, under the influence of bile and pancreatic fluid, becomes acid after an hour or so. Fats excite not only a free secretion of pancreatic juice, but also an increase of lipase. Water is likewise a direct and independent exciter of the nervous mechanism of the pancreas.

Enterokinase (eukinase, zymolysin) is a substance found in succus entericus and saline extracts of the duodenal mucous membrane, which is necessary to the tryptic action of the pancreatic juice. Pawlow explains the secretion of the proteolytic ferment of the pancreas in a latent form (trypsinogen), as being designed to protect the amylolytic and lipolytic ferments. The fat-splitting action of the pancreatic juice is increased fourfold by the presence of bile and enteric juice. Pancreatic digestion is at its height by the third to fifth hour after a full meal. The fat-splitting function is lost in the dried "pancreatin" of commerce.

The escape of the pancreatic juice into the substance of the pancreas or the surrounding tissues (as in acute hemorrhagic pancreatitis from invasion of bile, owing to gall-stone obstruction) causes disseminated fat necrosis. The foci of necrotic fat are opaque (normal fat, translucent), homogeneous and yellowish-white. They are not raised above the surface, as are tubercles or cancerous nodules.

Pancreatic calculi are rare and consist mostly of phosphate and carbonate of calcium, with a nucleus of animal matter. They are quite friable, usually rough, and may be faceted. They are soluble in chloroform, and yield on evaporation an aromatic odor.

INTESTINAL JUICE.

The succus entericus is a clear, viscid, light-yellow, opalescent, strongly alkaline secretion, containing a little over 2 per cent. of solids, of which about one-third is inorganic. This juice activates the proteolytic ferment of the pancreas, neutralizes the acids formed by fermentation of carbohydrates, and has marked glycolytic and lipolytic activities. The pseudopepsin of the fundus and pyloric part of the stomach and of the glands of Brunner acts in an alkaline as well as an acid medium.

MUCUS.

The protective fluid of mucous membranes is a glassy, translucent, colorless or opaque, stringy, generally acid secretion, containing 4 or 5 per cent. of solids, chiefly mucin. Microscopically it shows mucous corpuscles, epithelia, fatty granules, and sometimes cholesterin crystals. Mucus varies somewhat according to its place of origin. Thus, vaginal mucus is thin and acid, while that from the neck of the uterus is alkaline and resembles the white of egg.

Excess of mucus accompanies irritation or inflammation of the part affected, and favors fermentation. Nasal mucus under the microscope often appears in snail-shell spirals.

TEARS.

The protective secretion of the lacrimal glands is a clear, slightly alkaline fluid, containing 2 per cent. of solids, mostly NaCl, albumin, and mucus. There is normally a little less than 1 c.c. daily from each lacrimal gland. The so-called tear-stone is a calcified mass of fungus.

SEBUM.

The lubricating secretion of the sebaceous glands is an oily, alkaline semifluid, which becomes a white, greasy solid on cooling. It is composed of fat, soaps, cholesterin, lecithin, casein, phosphates, chlorids, and epithelial scales. Obstruction of the gland-ducts leads to the formation of "blackheads" or "flesh-worms," "wens," etc. The acarus or demodex folliculorum (hair-sac mite, pimple mite) is to be found at the base of nearly every "blackhead." The smegma of the external genitals; ear-wax, or cerumen, and the vernix caseosa of newborn infants are sebaceous in character. The cerumen contains a large proportion of K soaps and a very bitter yellow pigment. H_2O_2 is the best solvent for wax in the ear.

MILK.

The nutrient secretion of the mammary gland is a natural emulsion of fat-globules held in suspension by casein and calcium phosphate.

The average daily quantity of milk from a woman is about a liter; from a cow, six to ten liters (four times the body-weight in a year). The color is normally white or light-yellow, human milk having more of a bluish tinge than cows'. Milk is colored blue by the bacillus pyocyaneus; blue, slimy, and bitter by tyrotoxicon and by bacteria (peptonizing action of trypsin), which are usually held in check by souring species; purple-red by the micrococcus prodigiosus, and yellow by the bacillus synxanthus. It is reddish-yellow in rinderpest, owing to the presence of blood.

A bloody discharge from the mother's healthy nipple is rarely observed in neoplasms of the mamma. Ropy milk is caused by B. lactis viscosus during moist, warm weather. Inflammation of the udder imparts a salty taste to milk. Gassy milk is caused by bacteria present in manure particles. A drained rennet curd, kept about blood-temperature for several hours, shows that milk is unfit to use if there is production of gas (curd rises like dough) or foul odors. Certified milk ought to contain not more than 30,000 bacteria per c.c.

Breast-milk and cows' milk are both alkaline to lacmoid and acid to phenolphthalein on account of the presence of diacid and monacid phosphates, CO_2, calcium caseinate, and mucin. Lime-water and baking-soda do not alkalize milk (unless added in very large quantity), but may aid digestion by preventing the formation of dense curds. The sp. gr. of milk ranges from 1.018 to 1.045. Healthy human milk is from 1.028 to 1.033, with an average of 1.031. Healthy bovine milk ranges from 1.029 to 1.035. Breast-milk is thinner the less frequently it is taken.

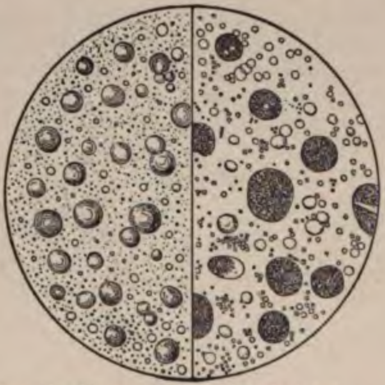


Fig. 61.—Human Milk and Colostrum.

The solids in milk amount to nearly 13 per cent. normally, varying from 8 to 16 per cent. These comprise chiefly casein (3 per cent. in bovine, 1 per cent. in human), lactalbumin (0.5 per cent. in cows', 1 per cent. in woman's), fat (4 per cent. in woman's, 3.7 per cent. in cows'), lactose (6 per cent. in human, 4.5 per cent. in bovine), and mineral salts (0.2 per cent. in woman's, 0.7 per cent. in cows'), mostly $Ca_3(PO_4)_2$,K_2CO_3, and calcium citrate. Milk contains more lime to the liter than liquor calcis. Other salts are the phosphates of Mg, K, and Na; the chlorids of K and Na, and a trace of iron. Other proteins in traces are lactoglobulin (probably identic with serum-globulin), nuclein, pepton, albumose, urea, myristic acid, opalisin (protein rich in S—human milk), dextrin (cows' milk), and albuminoids. Still other unimportant ingredients are lecithin, leucin, creatin, and about 8 per cent., by volume, of gases (O, N, and CO_2). Milk is deficient in iron, but infants contain in their tissues a store of this metal that is slowly used up during the period of suckling. The composition of milk varies considerably from day to day, and the strippings are seven times as rich as the first few drops.

Milk contains several enzymes, particularly an oxidizing ferment, absence of which shows that the milk has been heated to preserve it. Cows' milk contains a trypsin; human milk, a diastase.

Experiment.—Shake 10 c.c. of milk with 1 c.c. tinct. guaiac and 5 c.c. each of turpentine and H_2O_2 solution. A blue color appears when the oxidase is present.

Experiment.—To distinguish boiled from unboiled (or pasteurized) milk, make a fresh, weak aqueous solution of diamidobenzene, and add this to some of the milk in a test-tube, along with a few drops of H_2O_2. Unboiled milk gives a deep blue color at once—boiled milk, no appreciable coloration for a considerable time.

The casein of milk is not in solution, but is held in granular suspension as a neutral Ca salt; it can be filtered out by a clay filter as a fine, white powder. It dissolves readily in alkalies or mineral acids or dilute salt solution, and reddens moist litmus-paper. It does not coagulate on boiling, but, along with Ca, forms the scum. It coagulates quickly with acids or lab-ferment (rennet) in the presence of $Ca_3(PO_4)_2$, with which the casein unites to form the curd (paracasein), a small quantity of whey albumose being formed at the same time. The coagulation of milk is retarded by boiling (CO_2 driven off, which held lime salts in solution), and is favored by adding lime-water.

Human casein can be pptd. by saturating with $MgSO_4$. It forms a finer, more flocculent, and more digestible coagulum than cows' milk. Phosphocarnic acid is split off from human casein in digestion, and is peculiarly rich in P.

Experiment.—Fill two test-tubes one-half with milk, and to one add a teaspoonful of a good liquid rennet. Let stand for fifteen minutes. Then boil the milk in both tubes. Note that the milk containing the rennin gives a flocculent ppt., the other a heavy, curdy ppt. Quite fresh milk (except colostrum) does not coagulate on heating.

Lactose is nearly constant in quantity in the same person. It ferments spontaneously at ordinary temperatures into lactic acid, which removes the phosphates and ppts. coagulated casein, forming the curd; the whey is the thin liquid left after removing the curd. In the curdling of milk there is also a slight evolution of CO_2.

Casein and lactose are formed from a complex gluconucleoproteid in the mammary gland; lactoglobulin and lactalbumin are probably derived from circulatory proteins.

Butter-fat appears in small, refractive globules 0.0015 to

0.01 mm. in diameter (average, 3.7 microns), averaging about 1,000,000 per cu. mm. It contains traces of lecithin and cholesterin and a little yellow coloring matter (lipochrome). The coloring matter of milk is chiefly urobilin. Gravity cream should contain at least 18 per cent. fat; separator cream may reach 30 per cent. or more. Fresh separator creams show from 18 to 30 per cent. of total proteins as albumoses and peptons; two to four times as much as in fresh, whole milk. Centrifugal or pasteurized creams will not whip. Casein in butter favors fermentation. Whey contains from 6 to 8 per cent. solids, chiefly lactose, with about 0.5 per cent. albumin, a little fat, and about 0.6 per cent. mineral matter.

The acid, or alkaline, laxative colostrum of the first few days of lactation is nearly one-fourth solids (cows' sp. gr., 1.046 to 1.080; human, 1.040 to 1.060), containing an excess of fat and proteins (no caseinogen) and numerous colostrum corpuscles (epithelial cells including fat-globules).

Mothers' milk diminishes in fat and proteins near the weaning period. A fatty diet increases fat, but diminishes the quantity of milk. A vegetable and saccharine diet increases the sugar and decreases proteins and fat. Meats cause an increase in both fat and proteins, as well as in the amount of milk. A small meat allowance in a mixed diet increases casein and diminishes sugar. Alcohol taken by the mother or wet-nurse affects the nervous system of the nursling. Exercise lessens proteins. Hg, As, I, Pb, Br, laxative salts, turpentine, benzene derivatives, and volatile oils pass into the breast-milk when taken internally. Organic acids taken by the mother cause griping in the nursing infant. Worry, emotions, and menstruation increase the proteins and render the milk somewhat poisonous. Atropin, camphor, and antipyrin tend to dry up the milk; jaborandi, castor-oil, and alcoholics may increase its quantity; tea and coffee, by lessening appetite, may diminish the quantity of milk. An insufficient milk-supply is usually best remedied by the free ingestion of liquids, particularly broths, gruels (yellow cornmeal to increase fat), milk, and chocolate. The composition of breast-milk varies with unequal intervals between nursings; the shorter the intervals, the richer in fat. Mothers' milk with sp. gr. 1.018 to 1.024, and with only 2 or 3 per cent. cream, is irremediable (Holt). (See further under "Clinic Chemistry.")

SEMINAL FLUID.

The secretion of the testicle is a white, opaline, viscid fluid, containing, as its essential principle, the spermatozoa, which are mobile in the alkaline fluids of the body, but soon lose their power of motion outside the body. Nuclein is the chief constituent of the heads; albumin, of the tail. They also contain fat, lecithin (gives opalescence), and cholesterin, and are rich in potassium phosphate. The glue-like odor is due to spermin (C_2H_4NH), which, standing, forms characteristic dagger, or cuttle-bone, crystals. Spermin represents the active principle of Brown-Séquard's elixir, and is supposed to stimulate oxidation, the central nervous system, and the reproductive organs. The quantity of semen at each ejaculation ranges from 1 to 5 c.c.

The recognition of spermatozoa in stains is best accomplished, according to Simon, by soaking a fragment of the cloth or scrapings for an hour or more in a watch-crystal containing 27 to 30 per cent. alcohol, then teasing a bit of the matter in a 1 to 200 solution of eosin in glycerin, and examining under the microscope. The heads of the spermatozoa (which contain a chromatin nucleus) are stained deep red; the tails, pale rose. Vegetable fibers do not take up this stain.

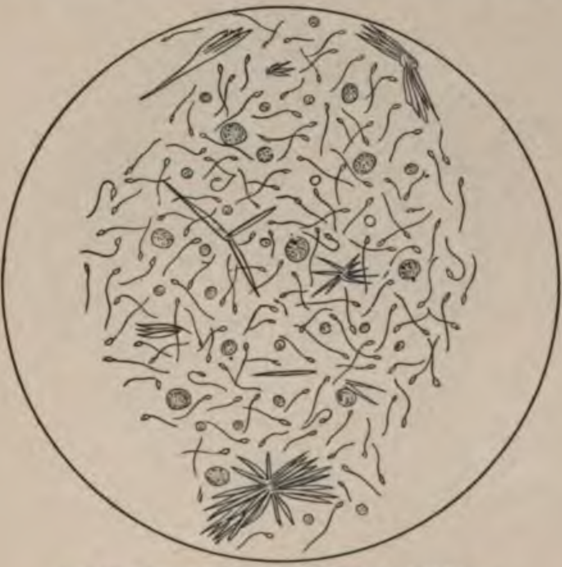


Fig. 62.—Spermatozoa and Böttcher's Crystals.

In addition to the spermatozoa, semen contains seminal and other granules, epithelial cells, and oil-globules. The major portion of an ejaculation consists of the secretion of the seminal vesicles, which contains many mucoid globules and some granular phosphates. The prostatic secretion is a thin, alkaline liquid, containing granular phosphates often grouped in colored microscopic concretions or sympexia. During sexual excitement Littré's follicles, Cowper's glands, and Morgagni's crypts pour forth a clear mucus like white of egg. This secretion is alkaline in reaction, and neutralizes and lubricates the anterior urethra. Chronic postgonorrheal prostatitis, aggravated by repeated coitus, may simulate gonorrhea. The sediment contains leucocytes, cylindric epithelia, fat droplets, laminated amyloid corpuscles, and many Böttcher crystals.

In azoöspermia the semen shows a normal odor and quantity, but is somewhat thinner and clearer, containing a few round cells, epithelia, and octahedral crystals, but no spermatozoa. In oligozoöspermia the semen has a few spermatozoa, showing sluggish movements.

Florence Test for Seminal Stains.—The reagent consists of 1.65 gm. KI, 2.54 gm. I, 30 gm. distilled water, forming KI_3 (iodureted KI). A minute fragment of the stained fabric on a glass slide is soaked for about a minute in a small drop of distilled water, and a cover-glass is applied. If the test is positive, the microscope shows at once characteristic brown prismatic crystals (from lecithin) resembling hemin. The test is very delicate, but is of negative value only, since it reacts to the decomposition products of lecithin present in many animal tissues.

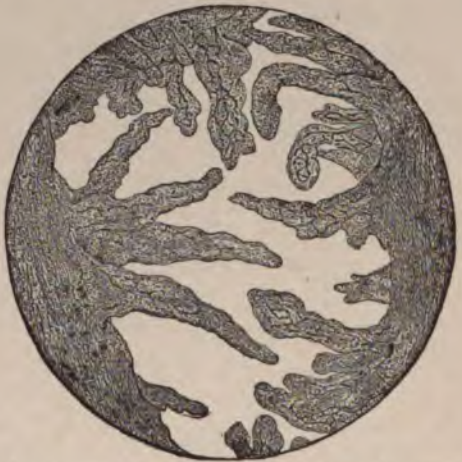


Fig. 63.—Chorionic Villi, from a Fresh Abortion (Low Magnification). (*Lenhartz.*)

VAGINAL AND UTERINE SECRETIONS.

The normal secretion of the vagina in virgins is always acid (bactericidal). It contains a variable number of leucocytes and squamous epithelia. An alkaline reaction (much pus with cocci) is noted in the diseased conditions of married women. Infusoria (cercomonas and trichomonas) are of no consequence.

From 180 to 200 c.c. is about the normal quantity of menstrual blood at each period. Lochia (after labor) include three varieties: rubra (pure bloody; squamous epithelia, and sometimes decidual remnants; first three days), serosa (like flesh-water; fatty pus cells, and sometimes cholesterin; fourth to ninth day), and alba (gray or light-yellow; composition like serosa; after ninth day). A putrid, dirty-brownish discharge is often the first danger signal of sapremia from retention of placenta, membranes, or blood-clots. The sickening stench of the dishwater discharge of uterine cancer is a valuable sign, but too often a late one.

Abortion (including extra-uterine) is shown by the presence in the clot of chorionic villi (tease tissue fragment and use low magnification), showing a capillary reticulum, sometimes with fatty degeneration; also large, round, polygonal or fusiform decidual cells with very distinct nucleus and nucleolus.

LYMPH.

This is a clear, colorless, or faintly yellow or red, alkaline, coagulable fluid, which constitutes the interstitial nutrient liquid of the body and carries into the blood the retrogressive products of metabolism. It makes up perhaps one-fourth the weight of the whole body—about 4 liters made daily in human veins. It varies considerably in composition in different regions, the solids averaging about 5 per cent. (chiefly albumin, neutral fats, and NaCl), and in sp. gr. from 1.015 to 1.021. The gases of the lymph are composed largely (35 to 45 per cent.) of CO_2. There is only a trace of O.

With the digestive lymph-wave the blood becomes more concentrated, showing an average rise of 15 per cent. in corpuscles and hemoglobin; 7½ per cent. in sp. gr.

Lymphagogs are of two classes: (1) crystalline substances, like salt, sugar, and urea, which increase the amount of water in the lymph; (2) those like peptons and egg-albumin, which increase the amount of organic solids by stimulating the endothelial cells of the blood-capillaries.

CHYLE.

This is nearly identic with lymph, except during absorption, when it contains considerable fat (over 3 per cent.), which gives it a creamy appearance, and more albumin (0.2 per cent.). It is strongly alkaline, and has a sp. gr. of 1.007 to 1.022. It is the mother-liquid of the blood. As it passes from the intestine into the receptaculum chyli it loses albumin and fat and takes up corpuscles and fibrin, thus becoming coagulable.

CEREBROSPINAL FLUID (BRAIN LYMPH).

The meningeal fluid obtained by lumbar puncture is clear (unless purulent) and frankly alkaline; sp. gr., 1.004 to 1.007. It contains less than 1 per cent. of solids, chiefly K and Na salts, and a trace of globulin (above 1 per cent. in severe inflammations). The average percentage of proteid in general paralysis is about ¼ of 1 per cent.; three times as much as in spina bifida. Normal fluid contains a reducing substance, which is generally absent in pathologic cases. The fluid in general paresis, disseminated sclerosis, and neuritis contains an abundance of cholin, which is also present in the blood during seizures.

Diagnostic Information from Aspiration of Spinal Canal.—Tuberculous cerebrospinal meningitis: fluid usually clear, 1.005 to 1.011; proteins, 2 to 3 per mille (Esbach); tubercle bacilli in about half of cases. Acute non-tuberculous meningitis: fluid usually opalescent, sometimes purulent; diplococcus intracellularis, Fränkel's diplococcus. Chronic pachymeningitis: fluid usually clouded with blood. Apoplexy: pure blood (its absence may show extradural hemorrhage in certain cases). Cerebral tumors: rarely rich in albumin or leucocytes; sometimes small amount of sugar. Severe chlorosis: pressure greatly increased (violent headache). Syphilitic and parasyphilitic affections of central nervous system: hyperlymphocytosis (more than 5 lymphocytes to each microscopic field, × 400 or 500).

SYNOVIAL FLUID.

The synovia is a slightly cloudy, light-yellow, viscid alkaline fluid, containing about 3 per cent. of solids: mucin, albumin, fat, and salts (particularly earthy and triple phosphates). It contains a peculiar mucinous body termed synovin. The consistence of the liquid is increased by much use of the joint.

AQUEOUS HUMOR.

This contains the least albumin of any body fluid. When the crystalline lens is injured, albumin and globulin escape into the aqueous humor. The total solids amount to about 2 per cent., mostly NaCl.

INTERNAL SECRETIONS.

By this term is meant the specific non-excretory substances formed within glandular organs and given off directly to the blood or lymph. Like the secretions having external communication, these have a special function in the maintenance of health. The ductless glands seem to neutralize intrabiontic endogenous poisons.

The formation in the liver and muscles of glycogen from dextrose, and the reverse change, are among the most important examples under this heading. Experiments on animals and autopsies on the human body seem to prove that the islands of Langerhans of the pancreas furnish the blood or lymph with an internal secretion necessary either to the normal consumption of sugar in the body or to the control of the sugar output from the liver and muscles. According to Cohnheim, this substance, passing to the muscle cells, unites with another proferment to form still another ferment which has the power of destroying sugar rapidly. Blood-serum inhibits this glucolysis, which, according to Hirsch, takes place similarly, but to a less extent, in the liver. Adipolysis also appears to be a function of the internal secretion of the pancreas.

The function of the thyroids appears to be connected with metabolism (nutrition of connective tissue and nervous system), and thyroid extract increases nitrogenous metabolism. When these glands are extirpated or atrophied, the subject becomes diseased (myxedema). The essential thyroid secretion is thyreoglobulin (partly iodized and partly not; with thyreonucleoproteid, makes up colloid substance), from which iodothyrin is obtained by boiling with acids. Dry iodothyrin is an organic substance containing nearly 10 per cent. of I. The thyroids contain about 0.17 mg. As, as well as a phosphorized proteid.

The parathyroids are considered even more important than the thyroids, antidoting gastrointestinal poisons which produce tetany, convulsions, tachypnea, rapid heart action, and general fibrillary tremors.

The thymus gland contains a nucleoproteid (12 per cent.) particularly rich in phosphorus (3.5 per cent.). It functionates most actively during fetal life, its activity gradually decreasing to nil at the age of puberty. It appears to be connected with the growth of bone and nerve, and furnishes a good medium for the administration of nuclein. Hyperplasia of this gland accompanies status lymphaticus.

Suprarenal extract (colloid chromogen of adrenal medulla) is a true internal secretion and a most powerful vasomotor tonic ($1/_{4000}$ mg. adrenalin has produced distinct physiologic effects). It is used intravenously for shock and locally for preventing or arresting hemorrhage. The active principle, $C_{10}H_{15}NO_3$ (adrenalin, epinephrin, suprarenin, adnephrin), is an alkaloidal pyrrol derivative not decomposed by boiling. Suprarenal extract is a reducing agent, sometimes producing glycosuria by interfering with the oxidizing power of the internal pancreatic enzyme. The secretion of the adrenals arrests peristalsis (Ott); that of the spleen excites it. A synthetic product (methylaminoorthodioxyacetophenon), having properties similar to adrenalin, has been prepared. The high tension pulse of kidney disease is ascribed to excess of suprarenal secretion in the blood due to irritation of the adrenals by contiguous inflammation. Abnormally low tension is noted in Addison's disease, which depends usually upon tuberculous adrenals.

Test for Adrenalin.—$FeCl_3$ gives a dark green color, turning violet on adding a little Na_2CO_3.

The pituitary body is claimed by some authors to furnish an internal secretion relating to body-growth (acromegaly, giantism). The symptoms following the removal of this organ resemble those of thyroidectomy. The testes, ovaries, and other glands are also thought to exert special effects on the organism through internal secretions. The term hormones is applied to those activators or chemic messengers (simple, alcohol-soluble substances) formed in one tissue or organ for the purpose of stimulating another tissue or organ. Examples are secretin, epinephrin, thyroiodin. All glands contain an enzyme resembling or identic with trypsin. Arginase is an enzyme in the liver and intestinal mucosa; it converts arginin into ornithnin and urea.

Sajous concludes that the pituitary, thyroid, and adrenal glands form a functional triad upon which the life processes depend largely. The pituitary, according to this hypothesis, is a double sensory test-organ and sympathetic (vasomotor) nerve center. The thyroids and parathyroids secrete opsonin, which sensitizes tissues, bacteria, and waste products for oxidation. The adrenals furnish albuminous hemoglobin (Ehrlich's amboceptor), which takes up O in the lungs and carries it to all the cells; while the trypsin (Ehrlich's complement) of the leucocytes kills and digests bacteria.

EXCRETIONS.

Excreta differ from true secreta in consisting chiefly of waste-products which are no longer of any service to the organism. They pre-exist in the blood and accumulate in this fluid if not properly eliminated, giving rise to symptoms of poisoning. The principal waste-products of the human economy are urea, CO_2, H_2O, NH_3, the purin bodies, creatin, the inorganic sulphates and phosphates, the conjugate sulphates, and various pigments. The amount of urea excreted varies from 2 or 3 grains per pound daily, in sedentary adults, to 3½ grains per pound in active workers, and 6 to 10 grains per pound in children.

URINE.

This is the most important excretion, containing, as it does, nearly all the urea. It is generally much more concentrated as to urea than is the blood, owing to the selective vital activity of the renal cells. Excess of CO_2 causes swelling of the epithelial lining and restriction of the output. The water and inorganic salts of the urine appear to be eliminated by simple osmosis and diffusion from the capillary tufts of the glomeruli. There is always glomerular pressure, since the vasa efferentia are of smaller lumen than the afferentia.

The urea is secreted by a special selective action of the cells lining the convoluted tubules. When the nutrition of these cells is impaired by inflammation, malnutrition, or other causes, the urea is not fully excreted, and accumulates in the blood (uremia), while albumin and globulin escape from the blood into the urine. In healthy kidneys the surface tension of the urine is much greater than that of the blood, but is diminished in renal disease. The kidneys are said to separate alkaloidal poisons from infectious toxalbumins in the blood. The energy (osmotic pressure) required to secrete 1000 c.c. of urine is 185 kilogram-meters—six times as great as the maximum force of the muscles. (See also under "Clinic Chemistry.")

FECES.

The alvine evacuations are principally the unabsorbed residues of intestinal excretions. Normal feces (food completely digested and absorbed) have the same composition, and are derived from the intestinal wall. Ordinary stools consist chiefly of water (75 per cent.), insoluble and indigestible residues (7 per cent.) of cellulose, inorganic salts (1.2 per cent.), mucus and nucleoproteid, epithelia, fat-drops and fatty-acid crystals, cholesterin, indol, skatol, phenol, cresol, extractives, and bacteria. CO_2 is formed from the neutralization of the acid gastric contents by the pancreatic and intestinal juices, and by lactic and butyric fermentation. H is produced in large amounts on a milk diet. CH_4 is derived from cellulose and albumin. The bacteria in feces (53 to 400 milliards) are said to average one-third the total weight of solids—more in loose than in costive stools. The number in the bowel steadily increases from the stomach down. The bile acids and acids of fermentation produced in the intestine prevent protein putrefaction. The transit of food through the small intestine requires about two hours; through the large bowel, twenty to twenty-four hours.

The contents of the upper third of the small intestine are alkaline; of the lower two-thirds, acid (lactic, acetic). Putrefaction takes place chiefly in the large bowel (contents usually alkaline). The reaction of mixed food feces is normally neutral or slightly alkaline; occasionally acid from fatty-acid fermentation (diet rich in vegetables) or in biliary obstruction and acute enteritis; rarely quite alkaline, with triple phosphates, in typhoid and dysentery (with free bile and much chlorids and albumin). Normal mother's milk stools in infants are acid; cows' milk, alkaline (protein putrefaction). The odor is increased whenever the feces have been retained in the bowel much longer than normally.

The peculiar feculent odor is due to the putrefactive products (from tyrosin), indol (C_8H_7N), and skatol (C_9H_9N), along with H_2S, H_3P, methyl mercaptan, and butyric and valeric acids. A meat diet makes the stools smell stronger. The extremely foul odor of naphthylamin is sometimes noted after eating fish. Acholic stools are generaly fetid in odor. In the green, acid diarrhea of infants from fermentation of carbohydrates the feces smell sour. In the more severe leaden-gray, pultaceous form a putrid odor, due to albuminous putrefaction, is noted. The characteristic odor of cadaverin is marked in dysenteric and choleraic evacuations. In the gangrenous variety of dysentery and in syphilitic and carcinomatous rectal ulceration there is a very offensive rotten stench. Anyone, who has ever experienced the horribly fetid stench of tarry blood in the stools, can scarcely fail to detect another specimen of this character.

Diarrhea is in the main a result of overstimulation of the intestinal glands, by which nature endeavors to flush and cleanse the intestines. Infusoria causing diarrhea are the megastoma entericum, cercomonas, trichomonas and various amebæ.

The color of the feces depends normally on bacterially reduced bile-pigment (hydrobilirubin, stercobilin, urobilin), and varies from light-yellow on an alkalizing diet to a dark-brown on a concentrated acidifying (meat) diet. This reduction is not so marked in milk-fed infants; hence their stools in health are bright-yellow (bilirubin) or spinach-green (biliverdin). Colorless stools are rarely due to transformation of urobilin into leucourobilin, by further reduction, the color being restored by treating with acid alcohol or on standing (oxidation). Excess of unchanged bile renders the color of feces yellow-green, as in enteric catarrh and nervous diarrhea. When the elimination of bile is deficient the stools are pasty, clayey and glistening, largely from unchanged fat. White, fatty evacuations (or a yellow, oily liquid) are also noted in pancreatic disease, chronic lead poisoning, some cases of enteritis, and tuberculosis of the intestines and peritoneum. Whitish particles in the feces may be mucus (like white of egg), pus (creamy) or undigested casein (cheesy).

The nature of the diet has much to do with the color of the feces. Starchy foods impart a yellowish tinge; green vegetables (chlorophyl), greenish; cocoa or chocolate, gray; red wine or huckleberries, blackish. Many medicines also affect the normal hue. Thus, the salts of Fe, Bi, Pb, and Mn darken the stools, especially after standing, owing to the formation of the sulphid and oxid of these metals. Rhubarb, gamboge, senna, and santonin produce yellow stools; hematoxylon, reddish; calomel, sodium bicarbonate, colchicum or ipecac, green ("bilious"); methylene-blue, bluish-green.

The fecal evacuations are deep brown or black ("carbonized") from concentration in obstinate constipation or starvation. They are brownish-yellow, like pea-soup, in typhoid fever. The prodigiosus bacillus or micrococcus may give rise to the chromogen of red stools. The spinach-green color of the feces in the diarrhea of infants may be caused by biliverdin (stools acid) or by the bacillus of le Sage (stools alkaline), Shiga's Bacillus dysenteriæ or the Bacillus pyocyaneus.

Blood in the stools is bright colored if from the large intestine; dark and tarry (hematin), from the stomach or small intestine. Blood and pus appear in dysentery, ulcerative conditions generally, and perforations of extra-intestinal abscesses. A small bloody-mucoid stool is characteristic of intussusception.

Hematin may occur in the feces, physiologically, from a meat diet.

The evacuations are serous in cholera infantum. The rice-water appearance of albuminous cholera feces is due to large numbers of epithelia. Albumin is also found at times in the feces of typhoid, acute enteritis, and chlorosis. Pepton has been observed in the stools of typhoid, dysentery, perforative peritonitis, and tuberculous ulceration of the intestines. The ptomains have been isolated from the feces in cystinuria and Asiatic cholera. Catarrhal conditions are accompanied by excess of mucus (gelatinoid proctitis, particularly), sometimes forming pseudocasts of the bowel. Mucus from the small intestine is well mixed with the fecal matter. If particles of meat or large amounts of undigested food are visible to the naked eye, there is a severe lesion of the intestinal tract.

Leucin and tyrosin are found in cholera feces. Urea is excreted in considerable quantities by the intestine in uremic conditions. It quickly changes to ammonium carbonate, which by its irritating action on the mucous membrane causes the so-called critic diarrhea and vomiting. In constipation and fecal impaction water is reabsorbed and the excrement forms hard scybala with mucus.

The viscid meconium of the newborn owes its dark color to altered bile. Micro-organisms and their spores are absent till after suckling.

Intestinal concretions, bezoar, or enteroliths, are rarely met with in human subjects (mostly on milk diet), and usually have a nucleus of foreign matter. They may consist chiefly of earthy phosphates, of fatty matters, hairs, vegetable fibers (oatmeal), or insoluble medicines (salol, Bi salts). They are stony hard, sausage-shaped, and show concentric rings on section. Coproliths are inspissated feces (found in narrow parts of large bowel). Intestinal sand (grains of light color) consists of Ca and Mg soaps, cholesterin, bile-pigment, succinic acid, etc. This lithiasis is due to lithogenic catarrh of the colon, and is usually associated with mucous colic. False intestinal sand may consist of hard particles from pears, fig seeds, etc. The residues from bananas sometimes closely resemble tapeworm.

Test for Stercobilin.—Shake feces with saturated solution of $HgCl_2$; filter and float on chloroform, getting a rosy ring at the line of contact.

Estimation of Undigested Albumin in Stools.—Centrifugate, treat sediment with dilute HCl (removes mineral salts) and then ether (removes fats), and subject residue (cellulose and proteins) to digestion with artificial gastric juice. The difference between this first residue and what is left after the digestion represents proteins.

Test for Blood in Feces (Benedict).—Reduce stool to diarrheal consistence (if need be) by adding water; shake with gasolin, and make guaiac and ozonized turpentine test, getting, if positive, a blue color.

Weber's Test for Occult Blood (Austin).—Take a half test-tubeful of liquid feces, shake twice with ether to remove fat, and throw away this ether. Then add 5 c.c. of conc. glacial acetic acid (converts blood into acid hematin, soluble in ether), and shake again with an equal amount of ether. Preserve this ethereal extract and to it add a few granules of guaiac or aloin powder and dissolve, then add H_2O_2; shake well and allow to stand. If blood is present, solution turns blue with guaiac; red with aloin.

Identification of Mucus in Feces (Schmidt-Parisier).—Shake well a pea-sized piece of the solid material in a test-tube with 10 c.c. of 5 per cent. alcoholic solution of $HgCl_2$; allow to settle, pour off alcohol, and add 10 c.c. of H_2O, then a few drops of Ehrlich's triacid stain; shake well and let settle again; pour off staining fluid and wash with H_2O. Mucus is stained greenish; other proteins, brick-red. Unchanged bile turns green with $HgCl_2$.

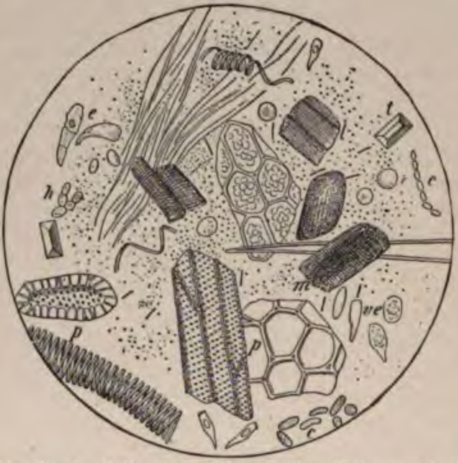


Fig. 64.—Stool. Collective Microscopic Picture. × 350. (Partly after *Nothnagel.*) (*Lenhartz.*) *m*, Muscle-fiber, *e*, Intestinal epithelium. *ve*, The same, "broken down." *c*, Clostridium butyricum. *h*, Yeast. *p*, Vegetable cells. *t*, Triple phosphate.

Strasburger Fermentation Test.—Take about 5 gm. feces and make a thin liquid with water. Pour into fermentation tube, so that no air shall remain, and place in brood oven over night. Little or no fermentation in normal feces. If upright tube should be half filled with gas, and reaction of liquid more acid than before, it shows excess of carbohydrates (smell of butyric acid); if alkaline (pus or blood), indol odor.

Microscopy of Feces (Austin and Lenhartz).—Collect stool in jar, stir with glass rod, remove a portion size of large bean to mortar, rub and add thymol-water (a drop of formalin may also be used as deodorant) until a thin fluid results. With the glass rod place a drop on each of 5 slides. Let one remain plain; to another add a drop of 10 per cent. acetic acid (dissolves soaps), and heat for a moment over flame; to another add iodoiodid of K solution (color starch blue); to another, sudan III solution (Ca soaps light colored, fats deep red), and to last a saturated $HgCl_2$ solution—colors muscle fibers brick-red if stercobilin is abundant—otherwise (closure of biliary duct) remains faint lemon-yellow (green from bilirubin).

Crystals of CaC_2O_4 are sometimes noticed after a vegetable diet.

$CaCO_3$ may appear in granules or dumb-bells. Wedge-shaped and "coffin-lid" phosphate crystals are often present. Spindle-shaped Charcot-Leyden crystals (spermin phosphate; like oat-grains; soluble in alkalies) and eosinophil cells are suggestive of entozoa, and have been noted in typhoid, dysentery and pulmonary tuberculosis. Hematoidin crystals may be observed after a hemorrhage or severe catarrh of the bowels. Cholesterin is rarely observed.

Blood can be distinguished microscopically only when from the lower part of the rectum. Pus cells occur from ulceration, dysentery or a burst abscess. Mucus is often present (catarrhal conditions and membranous enteritis); it is colored reddish-violet by thionin (other proteins blue). Structures like frog's spawn or boiled sago grains, says Nothnagel, are generally of vegetable origin. Fat in the stools may appear as driblets or crystals of soap or fatty acids. If the Cammidge pancreatic reaction (see under urine in "Clinic Chemistry") be obtained, and steatorrhea and azotorrhea also obtain, it is almost certain that there is some affection of the pancreas (Robson), which is verified by finding an epigastric tumor. Much connective tissue in the stools shows gastric indigestion. Epithelia in the feces are usually metamorphosed, and without a perceptible nucleus. They are increased in desquamative catarrhal conditions. Columnar epithelia (clouding mucus) are of frequent occurrence; squamous cells, very rare.

Muscular fibers and plant cells are often present in stools; starch, very seldom, unless there is marked catarrh. Starch granules (Hemmeter) enclosed in their cellulose envelopes are without significance, but if found free they indicate failure of amylolysis.

Yeast cells appear in groups of 3 or 4 buds, stained mahogany by Lugol's solution, which produces a similar stain with B. coli communis, B. lactis aërogenes (stools of infants) and B. putrificus (decomposing proteins). B. butyricus stains blue with Lugol's reagent. Many streptococci are present in the dejections of acute enteritis. Spirilla are often present in the mucous diarrheal stools of infants. Cholera, typhoid and tubercle bacilli are of great clinic significance. Corpora amylacea turn wine-red or dark brown with Lugol's. Keep a sharp lookout for the eggs of teniæ and other entozoa.

SWEAT.

The average daily amount of perspiration is from 700 to 900 c.c. (twice as much as from lungs). It is a highly aqueous liquid, containing only 1.2 per cent. of solids and having a sp. gr. of 1.004. The chief solids are the alkaline chlorids (especially $NaCl$), sulphates and phosphates, cholesterin, urea, and epithelia. The fatty acids (acetic, formic, propionic, caproic), lactic and sudoric acids, ethereal sulphates, and purin bodies are present when sweating is profuse. From 2 to 30 gm. CO_2 is given off by the skin in twenty-four hours. The amount of urea excreted by this route is markedly increased in cholera and uremic conditions, and glistening crystals thereof may sometimes be seen on the skin; vapor-baths have the same effect. In renal insufficiency the proportion of urea (normally about 1.5 per mille) may rise to 10 p. m.

Freshly excreted sweat is more or less turbid (fat and epithelia), usually slightly alkaline, but may be acid (NaH_2PO_4, and fatty acids); with a salty, somewhat acrid taste and characteristic odor. It may be colored yellowish from bile; blue or red from indican (cyanhidrosis, chromhidrosis), and red from blood. It is very acid in acute rheumatism and in rickets; strongly alkaline (ammoniacal) in uremia. The night-sweats of phthisis contain tuberculin. The salty sweat becomes bitter after large doses of quinin. It may be sweet in diabetes.

Iodin, iodids, organic acids, Hg, As, and other drugs may appear in the sweat after their administration. The skin eruptions sometimes following the ingestion of berries and shellfish may be caused by the local irritation of organic acids and intestinal decomposition products. The ill effects of coating the skin with varnish are due, not to checking of perspiration, but to resulting dilation of cutaneous vessels and consequent loss of heat. The sweat centers are excited by excess of CO_2 or by bile in the blood and by overheating.

The amount of perspiration given off in the closed palm during five minutes is normally about 75 per cent. of atmospheric saturation (Wetherill). In uremia it is greatly diminished (down to 30 per cent.); much increased in exophthalmic goiter. In the evaporation of sweat from the surface of the body, each pound represents about 1000 thermal units. An oily skin (Kellogg) radiates heat 50 per cent. more rapidly than a dry or unoiled skin. The loss of heat by evaporation ordinarily amounts to about 100 heat units per hour. Oiling the skin, previous to diaphoretic measures, aids in opening the ducts of the sweat glands.

VOMIT.

Vomiting of undigested food some hours after meals is noted in gastric atrophy or anadeny. Vomiting of well-digested food occurs in stomach neuroses, gastric ulcer, and acute or subacute gastritis and in central emesis. Morning vomiting of food taken the day before indicates some interference with gastric motility, usually accompanied by dilation and fermentation. Morning vomiting also occurs in alcoholic subjects and patients with chronic pharyngitis, from the swallowing of mucus and saliva. Bile and pancreatic juice are nearly always present in vomit when severe or protracted, and the former is readily distinguished by its color (bilirubin, yellow; biliverdin, green). A green color may also be due to mold (Knapp).

Bright blood is characteristic of gastric ulcer, in which considerable quantities are lost. Small amounts of blood are changed to hematin by the acid gastric juice, giving rise to the black, or "coffee-ground," ejections of gastric cancer and hepatic cirrhosis. A dark-red or chocolate-colored vomit, resembling blood, is likewise noted in the mold complication of organacidia gastrica, termed gastrosia fungosa. Pus in vomit is generally due to the perforation into the stomach of an adjoining abscess.

Test for Blood in Vomit.—Blood is recognized by the microscope, or by adding to some of the suspected contents a few grains of $KClO_3$

and 2 or 3 m. of HCl, warming and adding a few drops of a fresh solution of K_4FeCy_6. Prussian blue is pptd. if positive. Why?

Stercoraceous vomiting is easily recognized by the odor, and is indicative of intestinal obstruction. A feculent odor is also sometimes observed in cases of enterostenosis and in subjects with a fistula between the stomach and the intestine—rarely in fecal impaction or gastrointestinal neurasthenia.

The odor of vomit may be putrid in gastric carcinoma and in pyloric obstruction from any cause. An ammoniacal odor is observed in uremic vomiting; a garlicky odor in P poisoning; carbolic and hydrocyanic acids give characteristic scents to the vomit.

The regurgitated material from an esophageal sac or stricture is easily distinguished from true vomit by the total absence of all gastric elements.

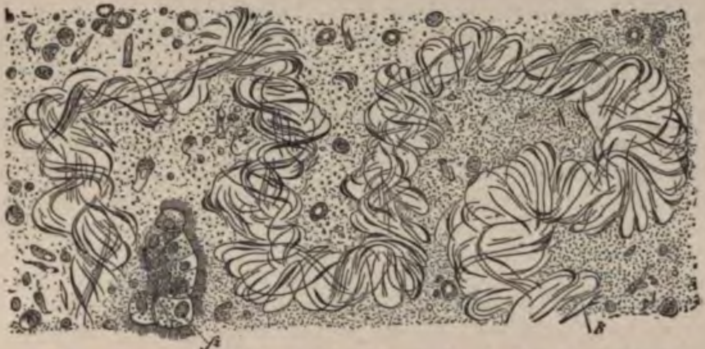


Fig. 65.—Curschmann's Spiral, Composed of Delicately Twisted Mucous Threads and Spindle-shaped Cells. × 350. (*Lenhartz.*) In the periphery normal and swollen cylindric and ciliated cells (*fz*); also eosino- (or baso-) phile cells and Charcot-Leyden crystals (*k*). The latter, however, are from other parts of the expectoration: *i.e.*, from another field of the microscope.

SPUTUM.

The chemistry of the sputum is of no great relative importance. The daily quantity may exceed a pint in cases with large cavities. The color and opacity depend chiefly on the contained leucocytes. The reaction is usually alkaline. The tenacity is due to contained mucus. The air content of simple mucoid sputum varies with the effort in coughing to raise it. The sweet taste of pus is due to the contained soap, masking the salty flavor of NaCl. The pus discharged from a ruptured empyema often smells like old cheese. A bad odor is likewise noted in tuberculous ulceration, bronchiectasis, and pulmonary abscess or gangrene. Tuberculous pus (Kolaczek) dropped into Millon's solution yields a firm film without coloration; non-tuberculous, a transient disk and soon a bright-red coloration.

The following crystals are occasionally met with: Hematoidin (bilirubin, aferrous, following extravasations of blood), cholesterin (stagnant pus), fatty-acid needles (putrid conditions; dissolved by heat or ether), calcium oxalate, triple phosphates, leucin and tyrosin (old pus foci), and the Charcot-Leyden crystals. These last are long, sharp octahedra, having the formula C_2H_5N. They are most frequently observed in asthma, and are chemically identic with spermin. They represent a retrogressive cellular metamorphosis and are found in decomposing viscera.

Particles of silica or stone-dust are observed in chalicosis; of coal-dust in anthracosis; of iron in the siderosis of grinders, and of kaolin in the sputum of potters and brickmakers. $CaCO_3$ concretions may come from the tonsillar crypts or from old pulmonary cavities, and the same is true of fetid cheesy particles (bacteria and fatty detritus). Rarely a blue tinge is noted in tuberculous sputum, due to ferrous phosphate.

The sputum of pneumonia contains as much as 3 per cent. proteid (never above 1 per cent. in phthisis and bronchiectasis). The fibrin coagula of pneumonia swell and dissolve in acetic acid. "Raspberry" or "currant jelly" sputum is noted in pulmonary carcinoma (fat-granule spherules and atypic epithelia). The bloody expectoration of hysteria resembles thin raspberry jelly. It is accompanied by a great number of squamous epithelia, and may persist for weeks. The sputum of asthmatics may contain a large number of basophilic (mastzell) cells. The "heart lesion" cells of brown induration of the lungs contain yellow to brownish-red or glittering black pigment, showing the Berlin blue reaction with K_4FeCy_6 in presence of a trace of HCl. Fatty detritus is especially abundant in purulent sputa. Elastic fibers show a breaking down of lung tissue, as in tuberculosis, abscess, and gangrene (putrefaction may dissolve the fibers); coarse, straight fibers are from food remnants. The granules in leptothrix buccalis stain blue with I, especially after acidulating with acetic acid.

CYSTIC CONTENTS.

Ovarian and parovarian cysts may contain either a clear, straw-colored fluid (red-brown if hemorrhagic) of low sp. gr. and with little albumin, or a dense, glairy, colloid material (1.018 to 1.024) with a large amount of serum-albumin, serum-globulin, and metalbumin. This last protein is very characteristic of ovarian cysts. It may be demonstrated, according to Simon, by mixing the fluid with three times its volume of alcohol, setting aside for twenty-four hours, and filtering. The filtrate on boiling becomes cloudy, without a sediment, however. It gives no ppt. with acetic acid, but with this acid and potassium ferrocyanid thickens and turns yellowish. H_2SO_4 gives a violet color, and boiling with Millon's reagent a bluish red. Cholesterin crystals are generally quite numerous.

Hydatid fluid is clear, alkaline, and non-albuminous; sp. gr. 1.006 to 1.010. NaCl is abundant, and succinic acid is usually present. Seeing the characteristic hooklets under the microscope is the final test.

The fluid of pancreatic cysts is recognized by its power of digesting starch, fat, or albumin in alkaline solutions. Milk may be employed as a test-medium, using the biuret reaction after pptg. the casein. A negative result does not exclude a pancreatic origin, since trypsin is not present in very old cysts. The fluid for testing must be sterile, since many organic ferments split starch and fat.

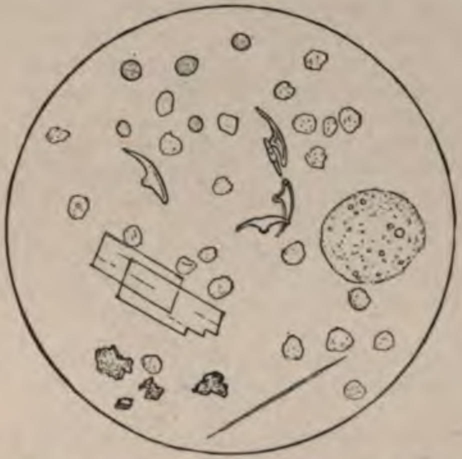


Fig. 66.—Echinococcic Hooklets, Obtained by Aspiration of a Cyst. × 350. (*Lenhartz.*)

Test for Steapsin (McGlannan).—Shake a gram of butter-fat in a test-tube with 5 c.c. of lukewarm H_2O, add a few drops of rosolic acid solution and enough Na_2CO_3, to give a pink color. Then add an equal volume of the fluid under examination, and digest at 40° C. for several hours. In the presence of steapsin the mixture will turn yellow (from liberation of fatty acids) in twelve hours or less.

Sebaceous or atheromatous cysts contain inspissated fat, fatty-acid needles, epithelial cells, cholesterin crystals, and leucin and tyrosin.

The finding of urea in notable quantities readily distinguishes a hydronephrotic cyst from any other, even when the liquid has no urinous odor. Renal epithelial cells are also quite characteristic when found. Red and white blood-cells are the chief microscopic constituents. The sp. gr. is always below 1.020.

TRANSUDATES AND EXUDATES.

The pathologic accumulation of fluids in the serous cavities and areolar connective tissue (under skin and between muscles) is termed an exudate when inflammatory in origin; a transudate when non-inflammatory (heart, blood, or kidney diseases). The sp. gr. of exudates ranges from 1.012 to 1.030 (the older, the denser); of transudates from 1.005 to 1.015. The difference is attributed to the amount of albumin: 4 to 6 per cent. in exudates (2 to 2.5 per cent. in peritoneal), 1 to 2 per cent. in transudates. Exudates often coagulate spontaneously after standing twenty-four hours; transudates do not coagulate unless from the presence of blood. Considerable gas, chiefly CO_2, is frequently developed in these fluids. Pericardial effusion and hydrocele fluid do not coagulate unless pus or blood is added. In pneumonic resolution the fibrin and erythrocytes are dissolved by a kind of peptonization.

Transudates are generally serous and of a light-straw color (tinged reddish if blood is present); rarely they are chylous. Hydrocele fluid contains nearly 5 per cent. of serum-albumin and serum-globulin. Plates of cholesterin (sometimes forming a glistening pellicle) are often found in old serous transudations. Anasarcal fluid is clear and watery (1.005 to 1.010), and contains about 0.5 per cent. serum-albumin and 0.1 or 0.2 of urea. Ascitic fluid is yellowish, has a sp. gr. of 1.008 to 1.012, and contains from 0.7 to 0.9 per cent. of inorganic matter. It is chylous in tubercular peritonitis. Hydrocephalus fluid is below 1.0085 in sp. gr.

Exudates may be serous, serofibrinous (serosanguinolent), seropurulent, purulent, putrid, hemorrhagic, or chylous. Serous exudates resemble transudates, and have a sp. gr. usually above 1.008. Their sediment shows a flocculent coagulum containing a dense fibrin reticulum, but few red blood-cells (chiefly from puncture) and many multinuclear leucocytes (sometimes much enlarged).

Hemorrhagic exudates into the pleura are most frequent in cases of pulmonary tuberculosis and carcinoma, which are distinguished from each other by finding cancer-cells and fat-droplets and needles in the latter instance; tuberculous exudates are usually sterile, and are composed largely of small lymphocytes. In mechanic pleurisy endothelial cells predominate. Hemosiderin granules and clumps are often found in chronic hemorrhagic exudates.

Putrid exudates are brown or greenish-brown and alkaline (except from perforation of gastric ulcer), and are readily recognized by the odor. If a serous exudate is obtained on aspiration of an upper intercostal space, and a putrid in a lower, we may suspect subphrenic abscess.

Purulent exudates vary in color from gray-yellow to green-yellow (may become dark-blue from indican), and in sp. gr. from 1.020 to 1.040. They are alkaline when fresh (pleural may be weakly acid), and have the same chemic composition as white blood-corpuscles, with addition of pepton. The leucocytes are usually fatty. Empyema following pneumonia shows cocci and polymorphonuclear leucocytosis, and is likely to contain large clumps of fibrin. Leucin and tyrosin are often present in old abscesses.

Pus serum contains serin, globulin, albumose, albuminoids and many ferments, particularly oxidase. Chylous fluid owes its opalescence to fine albuminous granules. It is not cleared on adding NaHO and shaking with ether.

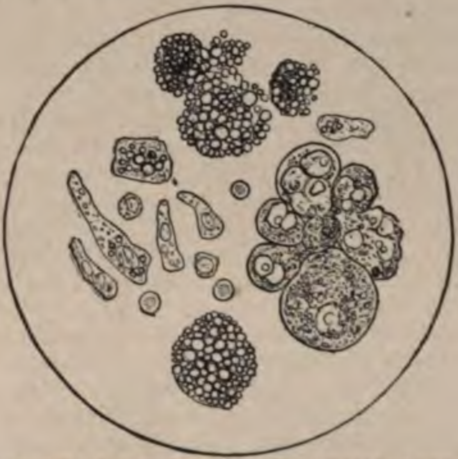


Fig. 67.—Fat-granule Spherules in Pulmonary Carcinoma. × 350. (*Lenhartz.*)

The fluid from uterine cysts differs from amniotic liquid in containing more albumin and but a trace of urea. This distinction is of some importance as regards watery discharges from the uterus during pregnancy.

False membranes consist of a fibrinous exudation with coagulation-necrosis of the underlying mucous membrane. They may undergo granular or hyaline degeneration, or may become organized and later sclerotic or even calcareous. The fungous granules of actinomyces are small, gritty, chalky particles, often with fat-granule corpuscles.

ANIMAL FUNCTIONS.

All the phenomena of the living body are caused, directly or indirectly, by chemic changes. Every pulse, every breath, action, and thought involves intricate reactions, which are more or less imperfectly understood. Most chemic reactions take place within the cells.

DIGESTION.

The process of digestion consists essentially of hydrolysis: *i.e.*, the taking up of water by food-products and their breaking down into simpler molecules capable of diffusion. The end-product of amylolytic digestion is dextrose; of proteolytic, pepton, or amido-acids. Fats are simply saponified and emulsified. The mixed acid products of digestion in the stomach are termed chyme. The term dyspepsia is properly applied to stomachic indigestion; dystrypsia, to intestinal indigestion. The stomach itself is not digested during life, probably because of the presence of anti-ferments in its walls, in much the same way as the addition of the juice of ascarides to fibrin prevents its being digested by pepsin or trypsin.

A small quantity of indigestible residue is of service in retaining food in the stomach by reflex pyloric contraction; fats and acids have the same effect. A liquid diet tends to pass at once from the stomach into the intestines. The unabsorbed residue in the intestines stimulates peristalsis and so regulates the conduct of the bowels. Free acid in the antrum relaxes the tonic pylorus, whereas excess of acid in the duodenum causes the pylorus to contract. At least 200 c.c. of CO_2 is formed after each meal (Benedict) by the reaction between the gastric and pancreatic juices; this gas serves as an important stimulus to intestinal peristalsis.

The continued addition of sodium bicarbonate to the food markedly depresses the secretory action of the pancreas. NaCl, also, according to Pawlow, is inhibitory to secretion, but may act favorably in acute catarrhal conditions of the stomach, by restraining glandular overaction. Simple bitters stimulate appetite and so aid digestion by the psychic contrast of pleasant foods. A slightly acid reaction of the food reacts favorably on appetite and digestion. Mild alcoholic drinks at meals may be of service, through their narcotic effect, in distracting the mind from daily toil and troubles. Eating sparingly often cures dyspepsia by preventing the overfilling of a weakened stomach, and by calling out the appetite juice in full strength when the sensory surface of the stomach is unable to fulfill its function. Broths and condiments serve a useful purpose by enhancing appetite, but should not be abused. Sweets at the close of a repast favor eupepsia and eutrypsia through their pleasant effect on the gustatory nerves. Milk is particularly available for sedentary brainworkers, since it is a direct excitant of gastric and pancreatic secretion, and neither requires nor awakes the psychic juice. Moreover, as shown by the nitrogen output, only one-fourth or one-third as much energy as for bread is expended in the gland metabolism of digestion. Much water in the system greatly aids the function of the gastric glands. Tea, coffee, and alcoholics inhibit the action of pepsin. Sterilized foods are liable to cause scurvy; the heat employed breaks down organic combinations of potassium and other metals, rendering them less assimilable. Canned and salt or smoked meats may also lead to scurvy, partly because of the toxic effect of the contained ptomains on the blood-cells.

A piece of well-masticated bread is changed by the ptyalin of the saliva into amylo- (amidulin, soluble starch), erytho-achroö-, and malto- dextrin, and partly into isomaltose and maltose. The amylolytic action of the saliva continues in the pyloric portion of the stomach for about a half-hour after the food is swallowed, or until the acid gastric juice permeates the whole mass—for two hours or more at the fundus. The conversion of starches into maltose is completed by the amylopsin of the pancreatic juice, which is by far the most active digestive secretion in the body. The maltose and any cane-sugar or lactose which may have been present in the bread are inverted by the invertase (maltase or lactase) of the intestinal juice. Hot, fresh bread and biscuits, when taken into the stomach, form a close, sticky mass like putty, which is very difficult for the digestive juices to penetrate. Cellulose is partly converted by bacteria into CH_4 and acetic and butyric acids, the last two being utilized by the body. The butter on the bread is not affected by saliva, but is liquefied by gastric juice, which seems to break down the membranes of the fat-drops, causing them to run together. In the duodenum it is acted on by both the bile and the pancreatic juice. The lipase or steapsin of the latter cleaves oils and fats into glycerin and fatty acids. These latter form a little soap with Na_2CO_3, and the soap emulsifies the remaining fats. The action of the bile is similar. The emulsified fluid becomes acid in reaction after one or two hours.

$$C_3H_5(C_{18}H_{35}O_2)_3 + 3H_2O = C_3H_5(OH)_3 + 3HC_{18}H_{35}O_2$$

A piece of meat or an egg is first changed to syntonin by the gastric HCl (meat and meat products take up from 5 to 15 per cent. of their own weight of the acid), then to primary albumoses (proto-, hetero-, gluco-), secondary albumoses (deutero-), peptons and polypeptids (bodies not giving biuret reaction). Peptic activity may be inhibited by excess of HCl.

Fibrin swells up, becomes transparent, and is corroded by the gastric juice; by trypsin it is first changed to globulin. The connective tissue of flesh foods is first attacked and peptonized by the gastric juice. The nuclei of meat cells are digested only by the pancreatic juice. Collagen is first changed to gelatin, then to acid albumin, protoalbumose, deuteroalbumose, and gelatin pepton. Elastin is changed only to protoalbumose. Gluten (sometimes used as capsules) is not dissolved in the stomach.

Myosins and globulins become myosinoses and globulinoses, and then peptons. Nucleoproteids leave a residue of nuclein, called dyspepton in the case of fibrin. Keratin is altogether indigestible.

Recent researches appear to show that antipeptons and amphopeptons do not exist as definite bodies, and that all digestible proteins are broken down and absorbed as simple crystalline end-products, or peptoids, such as the monoamido-acids (leucin, glycocoll, alanin; aspartic, glutaminic, and amidovaleric acids), diamido-acids (lysin, arginin, histidin), aromatic amido-acids (tyrosin, phenylalanin), and the thion body cystin—and that the various tissue-substances are formed synthetically from these comparatively simple compounds. Pawlow has demonstrated that the presence of the succus entericus is necessary to solution of albumin by pancreatic juice. Eukinase (enterokinase) acts as an amboceptor, binding the trypsin to the protein food.

Milk undergoes similar digestive changes to the three mentioned above, with the addition of a curdling process due to chymosin, owing to which it is retained longer in the stomach for digestion. The casein-jelly (tyrein) thus formed encloses the fat, and a soluble protein ("whey-proteid") similar to an albumose is split off from the paracasein. A clear fluid (whey) exudes from the curds; it contains albumin, globulin, and lactose. Paracasein itself is decomposed into paranuclein and the albuminous pairling. Milk is separated (Hammarsten) by rennin into paracasein (an acid) and other albuminous substances, uniting with Ca to form an insoluble salt. Rennin (or an accompanying enzyme) ppts. albumose-peptons. According to Pawlow, chymosin and pepsin are one and the same.

Experiment.—Digest in three porcelain dishes by means of (1) pepsin and (2 and 3) pancreatin, a small disk of egg-albumin, a dram of hydrated (boiled) starch, and a few c.c. of cod-liver oil. Test contents of first dish frequently for the digestive products syntonin, albumose and pepton; of the second for dextrins, maltose and dextrose, and note rapid saponification and emulsification of oil. The pepsin dish is best kept in a thermostat at 38° to 40° for two hours or more. The amylolytic process can be finished at about the body-temperature in less than a half hour. Take care not to heat much above this point.

Intestinal bacteria aid slightly in digestion, especially the liquefying ones, but their chief action consists in the production of skatol, indol, phenol, cresol, NH_3, H_2S, leucin, tyrosin, aspartic acids, and tryptophan from proteins (glycocoll from glutin); lactic and butyric acids from starches and sugars; fatty acids from fats, and CH_4 and CO_2 from cellulose. The chief fermentation products in the stomach are alcohol and lactic, acetic, and butyric acids. Bacterial action is more marked in the large (less peristalsis) than in the small intestine, and is increased by deficiency of HCl. Cellulose is not transformable without the intervention of microbes (symbiotic action). These germs are mostly insusceptible of cultivation. If the alimentary tract is placed in conc. $HgCl_2$ solution after death, it will turn green (bilirubin) above the ileocecal valve, and red (hydrobilirubin—from putrefaction) below this valve.

Sahli's Test for Proteid Digestion in the Intestines.—Give patient a gelatin capsule previously hardened in formalin (hence almost unaffected by the gastric secretion) and filled with iodoform. The iodin reaction should be obtained in the urine or saliva in from 4 to 8 hours. Absence or delay of reaction, with normal mobility of the stomach, indicates impairment of pancreatic digestion. Normally 85 to 90 per cent. of meat protein is digested; 75 per cent. of vegetable protein; 95 per cent. of fats; carbohydrates generally completely digested, except cellulose.

ABSORPTION.

The process of absorption depends on osmosis and diffusion and on a special selective imbibition by the cells of the alimentary mucous membrane. A solution of low surface tension will osmose through a membrane into a solution of higher surface tension. Substances absorbed from the stomach generally do not give the biuret reaction.

Alcohol, sugar, dextrin, and many crystalloid medicines are absorbed to some extent from the mouth, stomach, and rectum, but the small intestine is the chief route of entrance for alimentary products. Water is not absorbed from the stomach to the extent of more than 10 per cent., nor by the lymphatics, unless in excess. In the large intestine calcium phosphate and other salts are absorbed along with considerable protein (10 per cent.) and much water. Absorption increases with concentration (up to 20 per cent.) in the stomach, but diminishes with concentration in the intestines. Absorption is aided by intraintestinal pressure and by the drawing power of the capillary blood-stream.

Proteins are absorbed into the blood (and lymph) as diffusible amphopeptons, albumoses, and amido-acids, which are dehydrated and regenerated (polymerized) by the gastric and the intestinal mucous membrane into the colloid serum-albumin and globulins of the blood. If a foreign albumin is injected under the skin, it soon appears in the urine, with which it is gradually excreted. The direct injection into the blood of proteoses or peptons has a toxic effect, and large doses may produce coma or even death.

Carbohydrates are taken up by the rootlets of the portal vein and carried to the liver chiefly as dextrose; but maltose, levulose, and lactose may also reach absorption in small quantities. Maltose is mainly changed to dextrose during absorption. The glucose is stored in the liver as glycogen, and is given off again gradually as dextrose to the muscles and other tissues. Senility, obesity, toxins, neurasthenia, and the gouty habit all interfere more or less with the glycogenic function of the liver or sugar consumption by the tissues, and may lead to glycosuria or diabetes mellitus. Experimental nervous lesions (floor of fourth ventricle) and injuries to the head cause a sudden expulsion of glycogen from the liver, with glycosuria. The most constant organic lesion in true diabetes is pancreatic disease. The ingestion of a large amount of sugar may cause temporary alimentary glycosuria from inability of the portal vein to take up all the sugar, whereas starch has no such effect. Cane-sugar injected directly into the blood cannot be utilized by the tissues, and passes out unchanged in the urine.

Fats are absorbed (up to 300 gm. daily) by the lacteals almost entirely in the form of a fine emulsion or chyle. Free fatty acids, glycerin, and soaps appear to be regenerated into fats, under normal conditions, by intracellular lipase. The granules of leucocytes appear to take up fat in a soluble form and synthetize it into neutral fat. Fats with low m.p. and free fats (butter, lard) are better absorbed than those surrounded by connective tissue (ham).

The bile greatly aids the absorption of fats by its lubricating action on the mucous membrane and by dissolving fatty acids and glycerin. Hence in liver disease there is much waste of fat in the stools. In disease of the pancreas fat absorption ceases, except in the case of milk (about half in total destruction), a natural emulsion. The digestion and absorption of proteins and carbohydrates are also greatly impaired.

The average absorption from a mixed meal during health (Atwater) is 92 per cent. proteins, 95 per cent. fats, 97 per cent. carbohydrates. Recent investigations appear to prove that the leucocytes are the active agents in absorbing the salts of the heavy metals. Hg is taken into the blood as an oxyalbuminate. The normal average absorption of Fe in the food is not more than 10 mg. daily.

Highly crystalline substances (KI, LiCl) are absorbed within five to fifteen minutes after their administration by the mouth. Others—salol and keratin-coated pills, for example—are not acted on by the gastric juice and are not absorbed from the intestine and found present in the urine for two hours or longer. The gastric HCl appears to hinder exosmosis. Strychnin solutions and opiates are absorbed more quickly from the rectum than from the stomach. During the passage of the contents through the large intestine—a period of twelve to twenty-four hours—much water and some nutriment are absorbed from them.

Rectal enemas are digested probably by pancreatic ferments passing through the bowel, and by the succus entericus. Egg-albumin, fats, and milk can be absorbed (best with a little salt) without being digested. Olive-oil (one ounce two or three times a day) is the only food-substance which can be injected under the skin without inflicting injury.

Any substance to be absorbed, generally speaking, must be in the liquid or gaseous state, but finely divided charcoal, taken internally, has been found in the mesenteric veins. The rate of absorption varies inversely with the density of solution. Concentrated saline solutions cause more effusion from the blood-vessels than absorption into these; hence such hydragog purgatives as Epsom salts should be given in a minimum of water to get the best effects.

Absorption is aided by low blood-pressure, and the saline infusions injected into the rectum or subcutaneously in cases of shock or hemorrhage are drunk up greedily by the vessels. Obviously the more rapid the circulation, the more quickly absorption proceeds. Absorption from the stomach is facilitated by the use of condiments and alcoholic solution or glycerin. Medicines administered hypodermically are taken into the circulation very quickly unless the tissues are waterlogged. Absorption through the unabraded skin seldom takes place unless rubbing is employed, as in mercurial inunctions. The absorption of poisonous gases (HCN) through the lungs is the most rapid cause of death.

METABOLISM.

The anabolic or constructive chemic processes of assimilation by which the end-products of digestion become bone and flesh and gland and nerve still possess more of mystery than of knowledge. From the transuded blood, or lymph, the parent fluid or soil, each differentiated protoplasmic portion of the organism takes those elements which are needed for its sustenance and structure, generally a loose and unstable combination of specially modified proteins, with inorganic salts. It is a curious fact that each of the circulating proteins shows minor differences when the blood is taken from different parts of the body. Catabolism includes oxidation and hydrolysis; anabolism, dehydrolysis.

Anabolic processes predominate during growth and convalescence; catabolic, in old age and cachexias. The final products of catabolism (catabolites) are excreted. Atwater has shown that there is no more metabolism with severe mental labor than with the most complete rest possible. The proteid molecule appears to consist of groups of banded amino-fatty acids. Hydrolytic cleavage must precede oxidation in the cellular fluids. The taking of food stimulates proteid metabolism, particularly in the muscles. The leucocytes are active in hastening the destruction of the more complex products of tissue waste.

It is thought that nutrients are changed in the body into (1) auto-oxidizable (reducing and easily oxidized) and (2) dysoxidizable (indifferent to molecular O) substances. The first kind are directly oxidized, causing the formation of atomic O, which attacks the products of the second class. By repeated cleavage and hydrolysis, energy results and waste substances are formed. O is even more important in the constructive (oxygenation) than in the destructive (oxidation) phases of metabolism, and oxidases may take part in this building of O into the living molecules.

The reversible action of the body enzymes doubtless plays a very important part in metabolism, by establishing a chemic equilibrium between the fermented substance and the products of its fermentation. Thus, fat is digested by steapsin in the intestine only when the resulting glycerin and fatty acids are removed about as fast as formed. In the tissue fluids, on the other hand, the dissociation products are in excess, the enzyme activity is reversed, and fat is deposited. During starvation the lipase acts directly, as during digestion, on the fat deposits of the body, and the fatty acids and glycerin of the cells diffuse into the blood. The liver seems to be concerned with catabolism of the body fat. Rennin, trypsin, diastase, and other enzymes excite the formation of antibodies. Antibodies in turn, when injected in an active state into new animals, bring about the formation of still other antibodies.

Lymphatic glands are of great service in the absorption and resorption of fat by means of the lipase which they secrete, and which has both an analytic and a synthetic action. Through this double ferment action the mesenteric glands in particular oppose inanition when alimentation is insufficient, and store up fat when alimentation is superabundant. They are functionally deranged by infections, which accounts for the prolonged emaciation following infantile diarrhea.

Protein foods and salts are absolutely necessary for tissue-building. To maintain nitrogenous equilibrium, the smallest daily quantity of absorbed protein required is 0.6 gm. per kg. of body-weight. Destruction of body-proteids is not influenced by atmospheric temperature, but is increased by fevers, and slightly by muscular work. In the digestion of proteins NH_3 is formed directly, the blood passing from the intestine to the liver containing two or three times as much of this compound as does the blood of the hepatic vein. Nitrogen in feces usually does not exceed 0.5 gm. in twenty-four hours. There is N retention between acute attacks of gout, with great loss of N in the feces during the paroxysms.

Carbohydrates are essentially producers of energy and heat. They can be formed from fats or proteins. The body-fat is derived from carbohydrates; to a minor degree from other fats and proteins (lack of oxygen). It is always a metabolic product (fatty degeneration). The adipose tissues serve chemically as potential reservoirs of heat. They are rapidly used up by muscular work, producing H_2O and CO_2. Carbohydrates spare the tissues more than do ingested fats.

The oxidation of these complex molecules, chiefly in the tissues (perhaps some fuel foods, such as fat, alcohol, and glucose, are partly burned in the capillaries), gives rise to animal heat and mechanic energy as results, and as products the simple and more stable compounds, such as CO_2, H_2O, NH_3, and urea. In other words, potential energy becomes kinetic through the agency of protoplasm, with catabolic or destructive phenomena. Tissue or bioplasm proteid is supposed to break down at the rate of about 1 per cent. per diem. An acid reaction quickly destroys the irritability of bioplasm. Inorganic salts and NH_3 normally neutralize the acids formed by metabolism.

These two opposite processes of anabolism and catabolism go on constantly and almost simultaneously, and the life of the cell depends on the intramolecular atomic movements. According to Pflüger, in the living molecule N exists in the form of an unstable CN compound, which has the power to convert dead to living labile proteid by a process similar to polymerization or condensation. Catabolism, or the breaking down of living labile proteids, has been likened to putrefaction, with the evolution of N, H, and C, which combine with O and with each other to form the simple end-products NH_3, H_2O, and CO_2. Living protoplasm is believed to consist of "larger, secondary units" (physic or physiologic molecules, somacules), "each of which is a definite aggregation of chemic molecules, and possesses certain properties or reactions that depend upon the mode of arrangement." These somacules are suspended in a saline, alkaline, electrolytic fluid, and the protoplasm can be changed through gellation from the state of a hydrosol to that of hydrogel by heat, acids, electricity, or the abstraction of water.

Electrolytes and non-electrolytes stimulate a nerve by withdrawal of water, setting up a definite change in the colloids of the nerve, rendering the protoplasmic hydrosol unstable; also by the electric condition of the solution. The recent researches of Loeb and Mathews point to the proposition that what we know as life is in the main an electrochemic phenomenon due to the gellation of protoplasm and the liberation of free-moving ions of different valences, the cations being inhibitory, the anions stimulating in their physiologic effects. "Life" appears to be merely a convenient name for a series of physicochemic processes, which avowedly differ much in complexity from "inorganic" phenomena, but which have never yet been shown to differ from them in kind.

Experiment.—Add a little indigo-blue to a cane-sugar solution. The indigo is reduced by the sugar and loses its color (indigo-white). On shaking with free access of air the color is restored.

Muscular energy is accompanied by increased oxidation of fats and carbohydrates (glycogen), with no appreciable increase in proteid metabolism if the food-supply is sufficient. In muscles at rest much more O is taken up than CO_2 set free; the reverse obtains in working muscles.

The amount of CO_2 eliminated during ordinary muscular work is nearly double that while resting. Glycogen and the circulating glucose diminish or disappear from the active muscle, lactic acid being found. A rapid breaking down of assimilated food causes fatigue, partly from the ensuing deficiency of fuel-food, but chiefly because of the excessive accumulation of irritant waste-products.

Four-fifths of the energy liberated by chemic changes during muscular contractions appear as animal heat, and the remaining fifth of mechanic energy in the case of the cardiac and respiratory muscles is also converted into heat. The glands, particularly the liver, generate considerable heat, and the brain and nerves and alimentary canal liberate no small amount when in action. Animal heat depends primarily on the oxidation of fats, carbohydrates, and proteins in the capillaries (slightly, especially the pulmonary) and the tissues, with formation of CO_2, H_2O, NH_3, urea, etc., in a somewhat analogous manner to the production of smoke, steam, and ashes by the engine.

About 2500 calories are liberated during a day of repose. If the body-heat were all retained for twenty-four hours (Brubaker), the temperature would be raised 18° or 20°; 2.8 per cent. of heat is lost in warming food and drink, 3.8 per cent. in warming inspired air, 9.4 per cent. in evaporating water from the lungs, 15.3 per cent. in cooling the skin by evaporation, and 69 per cent. by radiation and conduction from the skin.

In fevers the cell-molecules are consumed faster than they are replaced, and body-wasting results. In infections, says Roger, fever probably represents a reaction of the organism against the hypothermic action of the microbes and their toxins. Initial chills serve as a rapid method of producing heat. Perspiration begins when the hypothermizing action of the toxin ceases, since reaction is now useless. In "cold sweats" diaphoresis accompanies vasoconstriction. Crisis, or the sudden disappearance of morbid manifestations, depends on a sudden neutralization of microbic poisons. It is most marked in diseases, as pneumonia, that begin suddenly, and is accompanied or followed by increased excretion. In chronic fevers the extractives due to defective metabolism are the active agents. The autogenic poisons are augmented in infected organisms through increased disassimilation and alimentary putrefaction.

One of the globulins present in various organs and tissues coagulates at 45° to 50°, and the physicochemic cause of death from hyperpyrexia is ascribed to the coagulation of this cell-globulin. Albumoses, peptons, and neurin in the blood excite fever. The temporary increase of body-temperature post mortem is due to change of myosinogen into myosin, and to other chemic changes. It is most marked after death from tetanus, typhoid, cholera, small-pox, acute rheumatism, and injuries to the brain.

The total available potential energy of any foodstuff is readily estimated by burning a certain quantity in a calorimeter, which is a sort of furnace surrounded by a given weight of water. From the rise in temperature of the liquid the number of calories, or "combustion equivalent," is calculated. In the case of proteins oxidation is not so complete within the body as without, urea, the chief product, not being completely burned. The combustion equivalent of urea is 2.523 calories. One gm. of proteid yields about ⅓ gm. urea; hence, to get the average available energy of protein food to the body 0.841 calories must be deducted from the theoretic equivalent: thus, 5.778 — 0.841 = 4.937. The equivalents of fats and carbohydrates are, respectively, 9.312 and 4.116 calories.

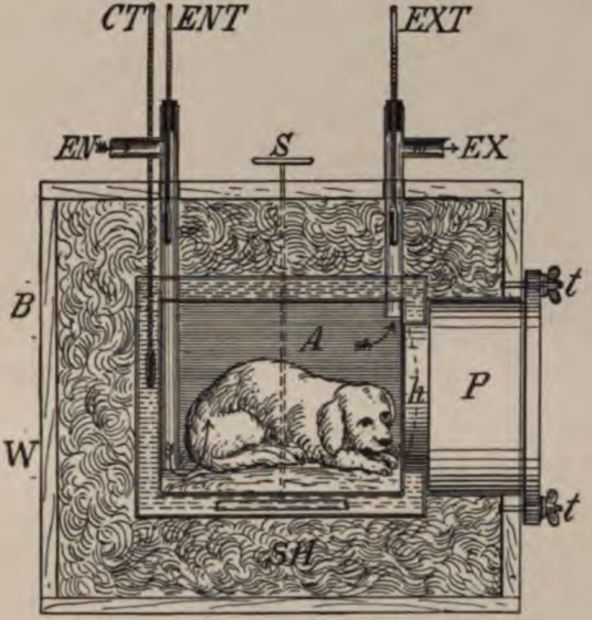


Fig. 68.—Reichert's Water-calorimeter.

Deducting waste, the net value in calories of each kind of food is for albumin 3.2; fat, 8.4; carbohydrates, 3.8. One hundred gm. of fat are isodynamic with 227 gm. of protein or carbohydrate. According to von Noorden, the body during total abstinence burns up about 1 gm. albumin and 3.5 gm. fat per day and kilo of body-weight. The body needs daily (Einhorn) for each kilo about 35 to 40 calories during rest, and 40 to 50 during hard work.

During starvation the circulating proteins are first drawn upon, then the body-fat (perhaps reconverted into dextrose), and then the muscles, to nourish other tissues and maintain body-temperature. Hence the loss of protein is greatest during the first day or two of fasting. A person fasting completely possesses no residual carbohydrates after the fifth or sixth day. A well-nourished adult, drinking an abundance of water, can keep alive without food for six weeks or more (without food and water, for seven to twelve days), while a delicate child would succumb within a week. Death from starvation supervenes with coma and delirium after the body-weight is reduced from one-third to one-half.

The elective affinity of the ingredients of glandular cells for certain waste-products in the blood, as of the kidneys for urea, is a chemic problem still unsolved. Cell nutrition is probably allied to the immunizing, bactericidal, hemolytic, and precipitating functions of cells and sera.

According to Ehrlich, only those substances can be chemically incorporated with the protoplasm (assimilation) which possess a grouping closely related to some constituent of the cells, fitting into its constitution as a key into a lock. The formation of true secretions by gland-cells, as HCl and pepsin, must depend, in general, upon a specialized protoplasmic metabolism. These cells in giving forth their secretion products seem themselves to break down and dissolve. The possible uses of the waste-products of one tissue for the needs of another is exemplified by the burning of sarcolactic acid to form uric acid. Cells have many latent powers, which are brought into action by proper stimuli.

The interstitial circulation of lymph from which the factors of metabolism are obtained and by which the waste-products are taken up to be excreted is maintained normally by a delicately adjusted osmotic and diffusion process. The diffusion of soluble constituents takes place continuously from the side of greater concentration to that of less (out of or into the capillaries), and is not dependent on the osmotic water-current; lymph may become more concentrated even than plasma. The blood-capillaries are more permeable to urea than to salt or sugar: a fact which favors the excretion of the former compound. The osmotic pressure of serum proteins is about 30 mm. in the capillaries (only 10 mm. in the lymph-vessels): a constant factor in promoting resorption from the tissues. Lymphagogs, such as sugar, extractives and neutral salts, increase the osmotic pressure of the circulating blood, thereby attracting water from the lymph and tissues, producing hydremic plethora, rise of capillary pressure, and great increase in transudation, and hence in the lymph-flow. Intracapillary blood-pressure is ordinarily 30 to 50 mm. Hg. When it falls below 20 mm., absorption of water from the lymph-spaces results.

When the balance is broken and transudation becomes excessive, we have the condition of dropsy, ascites, or anasarca. 5 to 6 gm. of NaCl are held in the system to retain each liter of water there in edema. Dropsic states are relieved by a dry diet and by diuresis and hydragogs, all of which promote low blood-pressure with increased osmosis into the capillaries.

RESPIRATION.

The respiratory changes effected in the blood, by diffusion and chemic attraction, are briefly a gain of O (7 per cent.) and a loss of CO_2 (8 per cent.). The latter is under high tension through the acid action of the red corpuscles and serum-albumin on $NaHCO_3$; about 5 per cent. of the gas is in simple solution. The O is taken up at once by the hemoglobin (0.26 volume per cent. free) and carried to the tissues, where O tension is *nil* and CO_2 tension high, and hence internal respiration takes place with a loss of O and a gain of CO_2. The O is probably united with the protoplasm in a somewhat firmer union than oxyhemoglobin. The minimal constant of dissociation of oxyhemoglobin is $\frac{1}{30}$ to $\frac{1}{10}$ atmosphere.

The O pressure is less by over 20 per cent. in the alveoli than in the nares. This tension of O in alveolar air is about 122 mm.; the tension of O in arterial blood is 29.64 mm.; in venous blood, 22 mm. The alveolar tension of CO_2 at sea-level is 38 mm.; in venous blood, 41 mm.; in arterial blood, 21.28 mm. The muscles have the greatest avidity for O of any tissues.

The volume of air respired at each respiratory act is about 500 c.c., equivalent to 450 liters per hour or 380 cubic feet per day. One-sixth of the air in the lungs is renewed at each ordinary respiration. There is a negative pressure in the air channels during inspiration; positive, during expiration. The air finds its way into the alveoli by diffusion and by the pump-action of the heart.

Expired air is saturated with water (20 to 40 gm. per hour) and contains traces of N, NH_3, and other organic effluvia, which give rise to the bad odor of ill-ventilated sleeping-rooms. Air at body-temperature absorbs eight times as much H_2O as at the f.p. of the latter. Exhaled air contains 0.9 per cent. more N on account of absorption from the bowels. Inspired air contains nearly 21 per cent., by volume, of O and 0.04 volume of CO_2. Expired air contains 16 volumes per cent. of O and 4.38 per cent., by volume, of CO_2. During sleep the gaseous exchange is diminished by one-fourth. The temperature of expired air is raised to 36.3°, and the actual volume of air is diminished 2 to $2\frac{1}{2}$ per cent., when allowance is made for the expansion (10 to 12 per cent.) caused by the rise in temperature to nearly that of the body. The "respiratory quotient" is obtained by dividing the quantity of O inspired ($1\frac{1}{2}$ pounds daily) into that of O expired as CO_2 in the same period. It is usually about 0.9 ($4.38 \div 4.78$), but varies with the diet, being nearer unity with hydrocarbons, and down to 0.75 with fats and proteins.

The critic temperature for an animal species is that at which the gaseous exchange and resultant heat liberation are at their minimum, increasing automatically below this point.

Cutaneous respiration in man is of minor importance, the ratio with pulmonary respiration of O absorbed being about 1 to 100; and of CO_2 eliminated, 1 to 200-500.

Dyspnea develops when inspired air contains less than 13 volumes per cent. of O, and is also caused by excess of CO_2 in the blood. The cyanosis observed in asphyxia from deprivation of air is due to the nearly complete reduction of oxyhemoglobin.

According to Dalton's law, the amount of a gas dissolved in a liquid varies directly with the pressure of the gas. The proportion of O in the blood is fairly constant, no matter what the pressure, because of its occurrence in loose chemic combination.

The hemorrhages and other symptoms of caisson disease are attributable largely to the sudden escape from the blood of air (N, especially) which has been forced in under high pressure.

SMELL AND ODORS.

Smell is the subtlest sense of all, and in appropriate instances is of greater delicacy than spectroscopy. Man's sense of smell is more extended, but less intense, than that of many lower creatures. Fatigue from overstimulation by one odor causes temporary loss of perception for this odor.

The mechanism of olfactory stimulation has generally been held to be due to fine solid particles or gaseous exhalations dissolved in the mucus in the upper chamber of the nose; hence we sniff to perceive a scent more acutely. When the Schneiderian mucous membrane is dry, the sense of smell is lessened or lost, yet odoriferous substances in the liquid form are incapable of giving rise to odorous sensations (Kirkes). Aitken believes that the sense of smell is excited by gases given out from substances, and not by solid particles; sewage does not communicate motes to the atmosphere. The flavor of foods depends largely upon their odor, and when the nose is much obstructed apples and onions differ little as to taste. Acrid substances, like ammonia, mustard, and horseradish, act on the common sensibility of the nose and eyes.

Zwaardemaker's chemic classification of odors is as follows: Ethereal odors (Rimmel's fruity series), from esters; aromatic odors, from terpenes, camphors and the spicy, herbaceous, rosaceous, and almond series, having as chemic types cineol, eugenol, anethol, geraniol, piperonal (heliotropin—from oil of camphor and oil of sassafras), and benzaldehyd; balsamic odors, including aldehyds and Rimmel's balsamic, jasmine and violet series, with the chemic types terpineol, vanillin and ionone (violets;

from a ketone in orris root; resembles oil of turpentine in composition); ambrosial odors, including ambergris, musk, and sexual odors (semen, pollen of grass); valerianaceous odors (capryl group), composed largely of sexual scents of fatty acid combinations; alliaceous odors (onions, garlic, mustard, horseradish, asafetida, ichthyol) and cacodyl group, containing S, As, Sb, P, Se, and Te compounds; empyreumatic odors (nidors) developed on burning animal (usually offensive) or vegetable (usually pleasant) substances; narcotic odors (heavy and depressing), in opium (narcotin), belladonna, lobelia, hemlock (coniin), tobacco (nicotin), anilin, benzol, and more volatile products of petroleum; bacterial (NH_3, H_2S, methyl monamins in decomposing fish, etc.) and fungous (sour milk, yeast, fresh earth), and pungent odors (ozone, NH_3, formaldehyd, SO_2, halogens, nitric acid, hydroacids and many organic acids, and their salts when moistened).

Odors are often due to impurities, as in acetylene, wood alcohol (tarry matters), sulphur (SO_2), fats and fixed oils (should be odorless, except lanolin and cacao butter), carbohydrates, glucosids, amaroids, coloring principles, and proteins. Illuminating gas owes its scent mainly to ethylene (sweet) and S compounds. All odors are reflexly and psychotherapeutically stimulant.

FOOD AND DIET.

The purpose of food is to sustain life; to produce muscular, nervous, and glandular energy and heat; to promote growth, and to prevent the too rapid destruction of the organic constituents of the body. The three chief classes of food principles are proteins, or tissue-formers, and the fuel foods, fats, and carbohydrates, both of which are chiefly producers of heat and energy, but muscular energy comes from all three classes. Proteins are also the source of the digestive fluids, and regulate oxidation and energy.

According to Atwater, 1 gm. protein furnishes the body 4 C.; 1 gm. fat, 8.9 C.; 1 gm. carbohydrates, 4 C. The human body utilizes as dynamic energy 19.6 per cent. (Atwater) of the potential energy of the food ingested. A steam-engine can utilize only one-eighth of the potential energy of fuel. The human body differs from other machines in having the power of self-renewal and self-adjustment.

The daily quantity of calories (heat, energy, and tissue-repair) required to keep the healthy adult human machine in good working order has been reckoned at from 2400 to 6000 (average, 3500), much more being needed when at hard muscular labor than when at rest. Such calculations are based mainly on examination of the excreta. Thus, 1 gm. $N = 6\frac{1}{4}$ gm. albumin $= 29.4$ gm. muscle $= 2.143$ gm. urea. Again, a man weighing 150 pounds gives off about 15 cubic feet of CO_2 in twenty-four hours, equivalent to 2400 foot-tons of energy. Allowance must also be made for the heat or energy required to keep up the body-temperature.

To maintain physiologic equilibrium an adult at moderate labor requires 35 calories per kg. of body-weight; a young infant at least twice as much. The skin surface of a child is relatively three times as great as that of an adult. Chemic regulation (absent in cold-blooded animals) prevents an abnormal fall in temperature; physic regulation (radiation, evaporation, distribution of blood) prevents abnormal rise of temperature.

It is possible for a person to live entirely upon proteins, but not upon a non-nitrogenous diet for any length of time. Nearly all foods contain more or less proteins: wheat, 14.6 per cent.; barley, 12.8 per cent.; oats, 17 per cent. An excess of proteid food above the amount needed to repair tissue-waste is burnt up into urea and excreted without serving any useful end; on the contrary, it overtaxes the liver and the kidneys, causing functional (lithemia) or organic disease of these organs.

Excess of protein increases heat production (secondary dynamic action) more than a corresponding excess of other foodstuffs; hence much meat is contraindicated in hot weather. When proteids are insufficient, water accumulates in the tissues. When proteid is metabolized, 71.4 per cent. of its energy-content is available for cell life, while 28.6 per cent. (12.7 per cent. fat; 5.8 per cent. sugar) is liberated as free heat in early cleavage (Rubner); 52.5 per cent. of the energy contained in meat proteid may be liberated as dextrose in the organism and be used directly by the cells (Lusk).

Excess of carbohydrates is stored up as adipose tissue. Fatty foods, it will be noted, yield much more heat than do proteins or carbohydrates; hence in winter and in cold regions people desire and require more fats. Abundant fats and carbohydrates prevent excessive destruction of proteins in ordinary work.

The most healthful and economic diet is evidently one so balanced as to nitrogenous and non-nitrogenous foods that there is no excess or lack of either. The proper proportion of N to C has been estimated to be about 1 to 15. Parke states that a workingman needs ⅔ oz. N and 8 to 12 oz. C daily. Another daily diet table is for proteins 110 gm. at rest, 118 gm. at moderate labor, 145 gm. at severe work; fats, 50, 55, and 100 gm., respectively, and carbohydrates, 450, 460, and 500 gm., respectively. Vaughan states that such requirements are most cheaply fulfilled by a diet of bread, codfish, lard, potatoes, bacon, beans, milk, sugar, and tea. In making a diet list, as Anders remarks, it may prove helpful to remember that 100 gm. meat represent 213 calories; a glass of milk equals 128 calories; an ordinary slice of bread (30 gm.) furnishes 64 calories, and 18 gm. butter yields 8 calories. The total weight of food *per diem* for an average adult should be about 60 oz. A slightly acid reaction favors gastric secretion and digestion.

The proportion of N to C in proteins is about 2 to 7; in albuminoids, 2 to 5½. In fats there is about 1 H to 7 C, with not enough O to burn all of the H, forming water. Carbohydrates have just enough O to oxidize the H, and the weight of H is ⅙ or ⅐ that of C. Organic acids have more than enough O to burn the H.

If a person were to live upon lean beef alone, 2 or 3 kgm. would be required daily to get enough non-nitrogenous elements; and of potatoes alone (less than 2 per cent. proteins), 8 kgm. would be needed to furnish enough N.

Fats and carbohydrates are more needed by the young, who seldom get fat on account of their greater activity. Fats, carbohydrates, and albuminoids save the tissues, and are especially indicated in chronic febrile diseases, such as pulmonary tuberculosis.

In addition to the three classes of nutriment above mentioned, water and salts are very necessary. Of the former, three pints or more daily should be drunk by the average adult in addition to that taken in solid food (50 to 60 per cent.). Potatoes are three-fourths water; watermelons, 94 per cent.; cucumbers, 96 per cent. A lack of water to flush the sewers of the body leads to constipation, malassimilation, melancholy, and many obscure aches and pains. Water is best taken mostly between meals, so as not to dilute unduly the digestive juices. A glass of ice-water taken at a meal drives the blood from the stomach and delays digestion at least an hour. Hot water escapes from the stomach much more rapidly than cold.

Common salt is the essential source of the HCl of the gastric juice, and since functional indigestion consists in hypochlorhydria in three-fourths of all cases, many dyspeptics find much relief from eating largely of salted meats, salted crackers, etc., though the primary effect of ingested NaCl is diminution of HCl. The reason why man and the herbivoræ require salt added to their food is explained by Bunge as due to the K salts uniting with the NaCl of the blood to form KCl, of which the excess now passes out of the system, causing thereby a loss of NaCl as well. Rice contains no K salts, and rice-eating races require no salt. Persons with defective kidneys should greatly restrict their food-salt, since this increases hypertension and edemas.

Of other food-salts the phosphates are most important, being bone-, brain-, and nerve- formers. Fish is richest in phosphates, particularly salmon (6 to 7 per cent.). Flake-barley contains 4.2 per cent.; oats, 3 per cent.; wheat, 1.6 per cent. The phosphates are just under the hard, siliceous coat and on the surface of the kernel. Butchers' meat contains about 2 per cent. of phosphates; ham, 4½ per cent., and beans, 3 per cent. Potassium phosphate is the characteristic constituent of cereal ash. About a grain of iron is consumed by a vigorous person in his daily food. An infant requires about 5 grains of lime daily; an adult, less. Milk contains most lime; next come eggs, then cereals (especially rice), radishes, asparagus, and spinach. Animals often die more rapidly when the salts are extracted from the food (chronic H_2SO_4 poisoning) than when deprived of all food.

ANIMAL FOODS.

These are generally more rapidly and completely digested than vegetable foods. Human milk is the ideal food for infants. Cows' milk lacks C as a sole article of diet for adults. It is usually quite fattening, partly because of its ready absorbability and partly because of the lactose in it. It predisposes to constipation, because there is hardly any residue left from digestion. The "bilious" effect of milk is obviated by adding 30 grains of common salt to each pint, and by eating fruits. Whey and junket are delicate dishes for the sick and convalescent, and buttermilk is often tolerated when rich milk is ill borne. Condensed milk is preserved by the addition of sugar, and while it fattens infants it is not nearly so nourishing as properly diluted fresh dairy milk. Dried milks or milk-powders are prepared by evaporating milk to dryness on revolving cylinders heated to 230° F. They keep well, are soluble in water and more digestible than ordinary milk. The milk of goats and asses is said to more nearly resemble human milk than does the milk of the cow, but the difference is too slight to be of account. Kefir is three times as rich in albumin as koumiss, and half as rich in alcohol and lactic acid. Matzoon is thicker than koumiss, and does not contain alcohol.

The milk proteins are partly decomposed on boiling, with liberation of H_2S. Milk that is pasteurized (heated 30 minutes at 70°) is less altered than when boiled, and yet nearly all pathogenic germs have been destroyed. Boiled milk requires two hours to digest. It is less digestible than unboiled milk, but curdles in small flocculi instead of large masses, and so is more thoroughly exposed to the action of the gastric juice.

Milk is rendered more digestible by warming with HCl, 5 or 10 m. to each pint. "Modified milk" for infants is prepared by adding separated cream, or by siphoning away the lower layer after standing in a cool place for three hours. Starches and predigested cereals are often added to cows' milk to prevent the formation of tough curds. As shown by the output of N, only ¼ or ⅓ as much functional activity is required of the digestive tract for milk as for bread. Milk keeps sweet longer in Zn vessels, because of neutralization of lactic acid by the metal.

Cheese contains up to 27 per cent. of proteins (chiefly casein) and up to 30 per cent. of milk-fat, with about 5 per cent. each of sugar and salt. It is highly nutritious, but somewhat indigestible unless very thoroughly masticated. The flavor of cheese is partly due to a "ripening" fermentation (chiefly lactic) by acidophilic germs, and partly to the breed and feed of cows. The tints of rich cheeses depend on the presence of various fungi. The practice of keeping cheese until it has been "cured"—that is, putrid from butyric acid fermentation (limburger, Roquefort)—is in contravention to all hygienic principles.

In digestibility the meat of fish ranks first (trout, 1½ hours), that of birds second (turkey, 2½ hours), mammals third (roasted beef, 3 hours; mutton, 3¼ hours; veal, 4 hours; salt beef, 4¼ hours; roast pork, 5¼ hours), and reptiles fourth. The flesh of young animals is less digestible than that of older. Meats contain from 25 to 50 per cent. of fats and proteins. The amount of water varies from 15 per cent. in dried bacon to 72 per cent. in lean beef and mutton. The proteins of meat are more completely digested than those of milk or vegetables. One-third the nutrient value of meat is lost by preserving with salt (Liebig).

The rotting of game until it is "high" aids digestibility by the corrosive action of sarcolactic acid on the sarcolemma, but it is a dangerous practice. Uncooked meat is liable to give rise to trichiniasis or a tapeworm. The brown color of well-done roast beef is due to hematin. The peculiar odor and flavor of meats depend largely on creatin and osmazome (developed by heating). Creatin is the chief ingredient of meat-extracts, which are stimulating, but not nourishing, and are excellent media for typhoid bacilli. They aid the system to digest and utilize gelatin. Meat-broth is usually acid, from the lactic acid in the meat. Of the 21 per cent. N in meat, about ¾ consists of extractives (beef most). Expressed beef-juice contains from 2 to 7 per cent. proteins coagulable by heat.

The so-called peptonized foods consist almost entirely of albumoses, and serve a useful purpose in many instances of malnutrition. If artificial proteolysis is carried too far, the products become bitter from some unknown substance.

Eggs contain egg-albumin and vitellin, ovomucoid, a ferronuclein, the common fats and a yellow lutein (lipochrome), a little dextrose, lecithin (11 per cent.), cholesterin, and chlorid and phosphate of K and Ca. Eggs are savory and digestible and very nutritious, but undergo putrefaction readily, often causing eructations of H_2S and H_3P. According to the observations of Beaumont on St. Martin, raw eggs are digested in 1½ to 2 hours; hard-boiled or fried in 3½ hours. A perfectly fresh egg appears almost translucent with the candle-test; very dark or even black when decayed.

Gelatin (0.6 per cent. Ca) is easily oxidized, and hence is a tissue-saver, though not a tissue-former. It is particularly useful for young children and invalids; 100 gm. gelatin = 36 gm. albumin. The "body" of beef soups is due to gelatin.

Animal fats are more easily digested and absorbed than vegetable fats. Fats promote the flow of bile and pancreatic juice, but if in excess interfere with or inhibit the gastric secretion.

VEGETABLE FOODS.

Bread is made from cereal flour and water, usually leavened by means of yeast. Only wheat and rye contain enough gluten to make bread. Wheat flour contains about 15 per cent. of water, 8 to 12 per cent. of gluten, and 60 to 70 per cent. starch; also sugar, dextrin, fat, and salts. The protein principles (estimated as N x 5.7) and phosphates are more abundant in the bran or cortic portion. White bread is, however, more digestible than that made from the whole wheat. Too fresh or poorly baked bread forms a putty-like, glutinous mass in the stomach, on which the gastric juice can have little effect.

Oatmeal contains more Fe and twice as much tissue-forming N as the same weight of beefsteak. Oats are especially rich in fats (5.11 per cent.), maize ranking next and rice lowest. The germ of some maize is rich in oil, causing such cornmeal to become rancid and moldy on keeping. It is the volatile oil of cereals which gives the odor. The MgO content of cereal seeds is always greater than of CaO.

Patent infant foods and most package breakfast cereals consist largely of dextrin, produced by heating wheat or barley. Grinding cereals ruptures the cells containing starch grains, which swell up and burst in a few minutes on cooking.

Potatoes contain about 20 per cent. of starch. The K salts (three times as much as in bread, partly united with citric acid) are just beneath the skin. Rice contains 75 per cent. of starch. K compounds are also important constituents of buckwheat and turnips. Asparagin, an amido-compound in potatoes and other vegetables, has no nutritive value, but is believed to limit intestinal putrefaction.

Pectose bodies make up the bulk (5 per cent.) of the carbohydrates of turnips (can be used in diabetes). Artichokes likewise have no starch, but gums and about 2 per cent. inulin.

Carrots possess considerable iron and about 10 per cent. sugar. Legumes contain vegetable casein (legumin and glutenin) and vegetable fibrin (gliadin and albumin). Beans, pease, and lentils contain about 25 per cent. of protein (legumin) and over 50 per cent. starch. Lentils contain no S, as pease and beans do. Peanuts contain more protein than true nuts. Herbs are superior as a class to roots and tubers in proteins. Green vegetables, as prepared for the table, contain only 1 to 3 per cent.

carbohydrates (useful fillers in diabetes), and are good vehicles for fat. The Fe in vegetables appears as hematogens (combinations with nucleins). The chlorophyl of green vegetables has no nutritive value, and leaves the body hardly changed. These legumes and garden vegetables are apt to ferment in the bowels, owing to the large proportion of water and cellulose they contain. For the same reason green vegetables must be used quickly after gathering.

Nuts are rich in fat [peanuts (a legume), 46 per cent.] and are hence very nutritious, but must be well masticated. The agreeable taste of fruits depends on the relative proportions of sugar, gum, pectin, acids (malic, citric, tartaric), salts, etc.; free acids are masked by gum and pectin. In the course of ripening some pectin bodies are converted into pentose (probably not nutritious).

Fruit-acids exist free and in combination with bases, particularly K. The ash of fruit always contains Fe—as much as 4 per cent. Fruit-sugar comprises sucrose and invert-sugar. All fruits contain tannin—enough in blackberries to constipate.

Unripe apples and pears contain considerable starch, which changes mostly to sugar during the ripening process. Fruit-acids stimulate digestion, and the cellulose, sugar, and water of fruits help constipation, for which purpose they are best taken before breakfast. Apples contain considerable phosphates and are digested in 1½ hours. Fruits are of little nutritive value. About 80 bananas would be required to furnish one day's energy.

The invert-sugar, produced partly in jams by boiling, agrees better with digestion than cane-sugar. If fruit is boiled too long, the power of gelatinizing is lost, and a syrup results instead of a jelly.

The volatile oils and oleoresins of condiments increase the flavor of foods and stimulate absorption and the flow of secretions, but must be used moderately, lest they irritate the mucous membrane. Condiments always stimulate movements of the stomach. Soup salts raise the osmotic pressure (normally 6 atmospheres) of the body-fluids considerably. Vinegar helps to soften the cellulose of beets and other vegetables.

Rice, barley, and tapioca remain in the stomach about 2 hours; legumes and potatoes, 2½ hours; white bread, 3 hours; brown bread, 4 hours. The stomach should be empty of all food in 6 hours after a meal.

COOKING.

To boil or stew meat properly the water must be boiling when the meat is put in, then be reduced in a few minutes to 160° or 170° F. and kept so till the meat is tender: that is, the tendons and fibrous tissues gelatinized. In this way the albumin and globulin at the surface coagulate, preventing loss of juices. The reverse process should be followed in making broths; the addition of salt helps to extract myosin. Vegetables (and rice) are better steamed than boiled, in order to retain their special virtues. Digestion of carbohydrates is aided chiefly by hydration of starches into soluble starch, dextrin and maltose. As ordinarily cooked, only about half the proteins from dried pease and beans is absorbed. Starch granules are surrounded by an envelope of vegetable fiber (cellulose). Cooking breaks down this covering and liberates starch as paste. In potatoes cooked till they are mealy, the watery part is absorbed into the starch cells. The N of potatoes is chiefly in the juice (causes waxy appearance on cooking, especially in young potatoes). A baked potato is more digestible than a boiled one, since the heat of the oven is usually about 200° F. higher than the b.p. of water. Legumin forms an insoluble compound with Ca salts; hence pulses should not be cooked with hard water (ppt. with baking soda).

For frying purposes the oil or fat should be boiling when the dough is put in. Otherwise the paste becomes saturated with grease and very difficult of digestion. Butter or lard is added to crackers to prevent them from becoming too hard and dry.

Roasting is best done in the open air, where the meat becomes more savory, digestible, and nutritious. Broiling, or grilling, and baking are modes of roasting.

The gliadin and glutenin of wheat unite in the presence of water to form gluten. The "sponge" is an actively fermenting mass of yeast and flour or glucose. "Salt rising" depends on enzymes normally present in flour. In baking bread the glucose (about 6 per cent.) produced from the starch of the flour is fermented by yeast into alcohol and CO_2, which causes the dough to rise, and on heating the loaf continues to expand until the gluten is coagulated and the bread sets in a vesiculated mass. The alcohol escapes into the air.

Good bread contains about 35 per cent. moisture, 8 per cent. proteins, and 55 per cent. carbohydrates. The crust is most digestible, being composed mainly of dextrin and caramel. Bread becomes sour from lactic and butyric acids when fermentation is allowed to go too far (alum prevents). A loaf of bread is not sterilized throughout by baking. The varying flavor of different batches of bread is due to minute quantities of lactic, acetic, and butyric acids, formed during fermentation. The freshness of stale bread is restored for a time by soaking in water and rebaking.

BEVERAGES.

Dilute alcoholic liquors increase the flow of gastric juice and are rapidly absorbed. They are not tissue-builders, but tissue-savers, as shown by decrease of urea, being burned in the capillaries into CO_2 and H_2O to the extent of 1½ or 2 oz. daily; 1 gm. alcohol = 0.071 calorie. Hence they are of service in some fevers. Alcoholics do not, however, give real strength, and are a poor food for muscular work. When used continually they probably combine with the nervous tissue of the brain, interfering with proper metabolism and predisposing to disease. Alcohol excites negative chemotaxis, and leads to hypoleucocytosis, thereby reducing resistance to infection.

Alcohol is itself an excretion of the yeast plant, and hence destructive to all higher organisms. Alcoholic liquors increase thirst by augmenting the elimination of water from the skin, lungs, and kidneys.

TABLE OF CALORIFIC VALUES. (AFTER FRANKLAND AND JÜRGENSEN.)
CALORIFIC VALUE OF 100 GRAMS IN CALORIES.

Apples	66.00	White of egg	67.10
Arrowroot	391.20	Flour	393.60
Asparagus	18.50	Flounder	100.60
Bean-soup	193.00	Macaroni	352.60
Boiled beef	209.00	Mackerel	178.90
Broiled beef	213.60	Milk	66.20
Raw beef	118.95	Skim-milk	39.61
Beef-fat	906.90	Oatmeal	400.40
Lean beef	156.70	Omelet	236.70
Bread-crumb	223.10	Pea-meal	393.60
Butter	814.00	Potatoes	101.30
Buttermilk	41.56	Pigeon	99.70
Cabbage	43.40	Green pease	318.00
Cakes	374.00	Salmon	133.30
Cane-sugar	334.80	Ground rice	318.30
Carp	93.00	Trout	106.40
Carrots	41.00	Veal cutlets (raw)	142.45
Chicken-breast	106.40	" " (broiled)	230.50
Cheshire cheese	464.70	Wheat bread	281.00
Cod-liver oil	910.70	" " (toasted)	258.80
Cream	214.70	Whiting	90.40
Hard-boiled egg	238.30	Zwieback	357.80
Yelk of egg	342.30		

The excessive use of malt liquors leads to the putting on of fat, from imperfect oxidation and elimination chiefly.

The alkaloidal beverages, tea, coffee (a cup contains 0.1 gm. of caffein), cocoa, chocolate, kola, and maté, are nerve-stimulants and are closely related to uric acid. Hence their continued use is likely to excite migraine and other uricacidemic conditions. Tea and coffee should always be prepared by a few minutes' infusion with nearly boiling water, as prolonged boiling drives off the aromatic flavoring oil and causes the water to take up a bitter astringent, tannin, a radical opponent of eupepsia. In addition to caffein (1.3 per cent.), caffeotannic acid, and the aromatic oil (caffeone, caffeol), coffee-berries contain fat (10 to 13 per cent.), legumin, sugar, dextrin, vegetable acids, and mineral salts. On roasting, the sugar is changed to caramel and the aroma develops. Tea contains about 3 per cent. of thein and 13 per cent. of tannin (more in green than black), as well as dextrin, glucose, MnO, and a volatile oil. The fermentation in making black tea renders the tannin less soluble. Milk added to tea or coffee makes these less obnoxious to eupepsia, by pptg. some of the tannin. Cocoa is the most nourishing of these drinks, since it contains 50 per cent. of fat and 18 per cent. of proteins, and a high percentage of potassium phosphate, besides gum, starch, coloring matter, etc. Chocolate is cocoa plus refined sugar.

Lemon-juice contains about 45 grains of citric acid per fluidounce. It is of special use in scurvy, which appears to be a mineral-acid intoxication due to an exclusive diet of meats or cereals, with a lack of alkaline salts (K particularly).

The prevalent practice of swilling soda-water, phosphates, and the like, during warm weather, tends to derange digestion through fermentation, and to increase heat production by oxidation of the sugar in these drinks.

AUTOTOXEMIA.

Autointoxication, or poisoning from within the body, is of great practical importance in the causation of various diseased conditions. The agents giving rise to autointoxication may be either pathologic chemic compounds or physiologic products in excess of normal limits. The general rule is that the waste products of any organism are deleterious to it and may cause death, sometimes suddenly, when reabsorbed in sufficient amount.

The poisons generated in the body, which lead to the abnormal cell-reactions of disease, are in general of intracellular (catabolic) or gastrointestinal origin, and are formed by autolysis, disassimilation, abnormal secretion, fermentation, and putrefaction. The toxicity of these products varies in proportion with the complexity of their molecules. By vitiation of the interstitial plasma they cause arteriosclerosis and degeneration of protoplasm, with increase of the nitrogen output. Autointoxication creates, by depraving nutrition, the "morbid opportunity" essential for the pathogenic action of the nearly omnipresent germs, which poison the body by means of their toxins. Conversely, autogenic poisons are augmented in infected organisms through increased febrile disassimilation and alimentary putrefaction.

The toxic endogenous substances giving rise to autotoxemia include the fatty acids (beta-oxybutyric causes diabetic coma), aromatic phenols (intestinal autointoxication), tyrosin (hepatic insufficiency), purin bases (uricacidemia, migraine, and gout; guanin from cancerous degeneration causes coma), diamins (putrescin and cadaverin in gangrene and carcinoma); mucin in myxedema; cholin in epilepsy; neurin in Addison's disease;

the amins (especially trimethylamin), acetone, special alkaloids, and leucomains, and the toxins generated by the colon bacillus, which is a constant habitant of the bowel. The production of indol depends largely on the activity of the colon bacillus, which ferments carbohydrates before acting on proteins. It causes (Kemp) headache, colic, diarrhea, neurasthenia, spasms, and cardiac and respiratory depression. Intestinal bacteria form phenol and cresol from tyrosin and break up lecithin into cholin.

Ethylidenediamin (Kemp) is a ptomain produced in dilated stomachs. Methylguanidin, formed in the small intestine, causes nervous irritability and convulsions, which are likewise produced by muscarin, putrescin, and neurin (dyspnea, unconsciousness). Depression and shock in intestinal obstruction are due chiefly to pentamethylenediamin, H_2S, and methyl mercaptan, formed in the stagnating contents of the bowel (Kukula).

The etiologic classification of Albu is as follows: Arrest of organic function (myxedema, pancreatic diabetes, Addison's disease, acute yellow atrophy); anomalies of general metabolism (gout, oxaluria, diabetes); retention of physiologic metabolic products (uremia or potassemia, eclampsia, cholemia, asphyxia, extensive burns); overproduction of physiologic and pathologic products (overwork, diacetemia, ammonemia, cystinuria, etc.); decomposition of food-substances arising from maldigestion. The last class is most common, and is usually accompanied by constipation, indicanuria, and neurasthenic symptoms. The urine of fifty-two hours (urea of sixteen days) or the bile produced in eight hours will kill a man. The carbon dioxid exhaled by one man in twenty-four hours would poison him lethally many times if retained. The blood itself is normally toxic to one-tenth the fatal degree. The saliva of some men is nearly as poisonous as serpents' venom (Brunton). The contained pigments account for one-third the toxicity of urine and two-thirds that of bile.

Lithemia, or biliousness, is, generally speaking, the manifestation of an overworked and long-suffering liver. The thyroid gland is involved in myxedema, cretinism, cachexia strumipriva, and exophthalmic goiter; the pancreas in diabetes mellitus; the liver in jaundice or cholemia, lithemia, acute yellow atrophy, and icterus gravis; the kidneys in uremia and eclampsia; the adrenals in Addison's disease; the lungs in CO_2 poisoning from interference with respiration; the gastrointestinal tract in the depressed nervous conditions accompanying constipation, indicanuria, and oxaluria; the skin in the phenomena following severe burns of large surfaces, and the pituitary gland in acromegaly.

Puerperal eclampsia is ascribed to temporary athyroidea, or thyroid inadequacy, proteids being converted not into urea, but irritant toxins. Iodothyrin is a vasodilator, diuretic and urea producer. Atrophy of the thymus gland is characteristic of infantile marasmus. Pathologic adiposity results after removal of or morbid changes in the sexual glands.

The manifestations of autotoxemia in any given case are usually manifold, and not confined to one organ. Nervous symptoms are the most frequent, and comprise headache, vertigo, syncope, irritability, insomnia, hypochondria, subnormal accommodative power, stupor, coma, delirium, spasms or convulsions, paralysis, melancholia, and mania; polymyositis has been noted in a few instances. Common cardiac symptoms are tachycardia, bradycardia, and arhythmia. The breathing may be stertorous or of the Cheyne-Stokes type. The temperature may be pyretic or subnormal, usually the first. Digestive symptoms include anorexia, nausea, vomiting, eructations, diarrhea, constipation, and colic. Toxemic disturbances of the urinary tract are manifested by albuminuria, hematuria, hemoglobinuria, choluria, acetonuria, diaceturia, and oxaluria. The skin may be anemic, jaundiced, or bronzed, and not seldom shows an erythematous, or urticarial, eruption, Cachexias are frequent, particularly those of cancer, diabetes, chlorosis, leukemia, pernicious anemia, and the uric acid diathesis. Infantile rickets, purpura, scurvy, and pernicious anemia are often of autotoxemic origin. Chlorosis is said to be a sequel of copremia.

Acid intoxications give rise to ataxia, dyspnea, rapid pulse, subnormal temperature, convulsions, and coma. Carnivorous animals are self-protected by the manufacture of NH_3 from their proteids. Oxybutyric acid is normally oxidized in the body into its keto-acid, diacetic acid, and this into acetone and CO_2, but in diabetes such oxidation is interfered with. The excretion of β-oxybutyric acid represents a much more advanced degree of oxidative perversion than does the excretion of diacetic acid or acetone. Its deleterious effect as to coma depends on its acid character in general, withdrawing alkali from the organism. These acetone bodies are probably intermediate synthetic products of normal metabolism. Alkali therapy protects the fixed bases of the cells from combining with pathogenic acids (diacetic and oxybutyric in particular) in the circulation. Von Noorden gives 15 grams or more daily of sodium bicarbonate or citrate in every case of diabetes showing the ferric chlorid reaction. In diabetic coma Naunyn injects intravenously 35 or 40 grams of sodium carbonate, repeating if need be.

Man is protected from autointoxication by the healthy action of his emunctories and by neutralization within the fluids and cells of the body. In this self-protection the liver is the chief organ of defense, oxidizing (by oxidases) and neutralizing poisons and excreting them in the bile. The liver oxidizes indol, for instance, into indoxyl and conjugates this with sulphuric acid, forming indoxyl potassium sulphate, a substance less toxic than indol and more readily excreted through the kidneys. The bowels are oftener loose than constipated in autointoxication, through nature's efforts to effect a cure by means of a salutary vicarious diarrhea. Vomiting is less frequent as a natural relief. The mucous membrane lining the intestines is excretory as well as secretory in action. Bile-salts and pigments are precipitated in the bowel and not reabsorbed to a great extent. The acid-fermentation products of milk and carbohydrates suspend the development of the ordinary saprophytic micro-organisms of the alimentary canal, whereas meat favors their growth. The kidneys are the chief organs of elimination, and extra work is thrown upon them when the liver is diseased. The skin and intestines can pass out in the same quantity of water only $\frac{1}{500}$ as much urea as the kidneys (Bouchard), hence their vicarious eliminative action is not important. Indeed, Bouchard asserts that perspiration is not beneficial in uremia, since it lessens the amount of urine, the chief depurant. He adds that the abstraction of 32 grams of blood carries off more poisons than 100 liters of perspiration. Connective tissue absorbs bile-pigment, and so protects brain and nerves. The lymph-glands serve as filters to bacterial products. Leucocytosis is the rule in threatened auto-intoxication.

"An ounce of prevention is worth a pound of cure," never more so than in autointoxications. A proper diet is of the greatest importance. Generally speaking, the amount of food should be lessened. Surgeons obviate autotoxemia preparatory to operation by starvation (Ochsner method). Milk, buttermilk, starches, and cereals prevent putrefaction in the bowels. Carbohydrates tend to lessen the amount of acetone bodies in diabetes, since they contain much oxygen. One should avoid excess of proteins (kidney and liver diseases), carbohydrates (adiposity, diabetes), fats (torpid liver, diarrhea, skin diseases), and nuclein foods (goutiness). We should observe idiosyncrasies to certain foods (eggs, strawberries, shellfish) as well as to medicines. Haig recommends in "uric acid" cases with high blood-tension a diet of bread and fruit with as little fluid as possible. Grawitz reports cases of pernicious anemia (intestinal autointoxication) cured with a diet of vegetables and cereals mashed or in porridge, with abundance of lemonade.

In the treatment of autointoxications elimination ranks first, and the necessity of a daily movement of the bowels has been recognized from the earliest times. A full dose of calomel, followed by some saline, is most effective in self-poisoning from the stomach and bowels, though in children who have eaten not wisely but too well castor-oil may be preferable. Constipation can often be controlled by drinking six to eight times daily a glass of water containing enough table salt to make the liquid half isosmotic with blood-serum. Stomach and bowel lavage is beneficial in almost any kind of poisoning. Apomorphin hypodermically is a quickly acting and efficient emetic. The skin should be kept active by washing, friction, and sweat baths, followed by cold douches, or sprays. Diuresis is best induced by enteroclysis with four to eight liters of physiologic salt solution. Saline infusions are especially serviceable to flush poisons out of the system. Stern advises using a hyperisotonic (1 per cent.) solution of sodium chlorid intravenously—up to 500 c.c. at 115° F.—every four to six hours if need be. Bleeding and vasodilators (aconite, nitroglycerin, veratrum) are indicated for the high tension pulse of eclampsia or anuria.

In acute autointoxication stimulants are often required to preserve the patient while the poisons are being eliminated. Atropin is very useful in antagonizing the neurin, cholin, and muscarin of meat poisoning. Inhalations of oxygen are of special service when the blood is disorganized and dyspnea is prominent. Abrams recommends as invaluable digitalin and strophanthin, alone or combined, for the relief of abdominal venous stasis. Motor functions are aided by strychnin.

The best gastric antiseptic is the natural one, hydrochloric acid, which prevents hypochlorhydric fermentation. Intestinal antisepsis can, of course, be only partially achieved, but "A half loaf is better than none." Intestinal antiseptics, particularly calomel, may do good in typhoid fever by preventing non-specific saprophytic autointoxication. Oliver claims that the phenols exert a depoisoning (combine with toxins) rather than germicidal effect after absorption. Bouchard prefers insoluble and non-absorbable antiseptics, such as naphthalin, bismuth salicylate, and iodoform. Other agents of more or less value are thymol, salol, beta-naphthol, oil of cinnamon (Caiger—3 to 5 drops, 0.18 to 0.30 c.c., three or four times a day), formic acid (Stern—2 to 5 drops, 0.12 to 0.30 c.c., well diluted with glycerin, every hour), pure brewers' yeast (1 or 2 teaspoonfuls of dried; 20 to 40 c.c. of liquid), organic peroxids, petroleum or olive-oil, fruit acids (Kellogg), bismuth subnitrate, salicylates, sulphites, and copper salts. Charcoal taken internally disinfects by fixing and oxidizing alkaloids, pigments, and other poisons in the alimentary tract. I have found phenolsulphonates (sulphocarbolates) quite efficacious, and it has long been my custom to give the sodium salt in full doses in acute alimentary poisoning, and in all chronic diseases accompanied by foul stools and indicanuria.

INFECTION AND IMMUNITY.

Most infectious diseases are known to be caused by the presence in the body of specific bacteria, which generate soluble poisonous, complex, non-basic protein bodies, or toxins, that act as the direct cause of all the morbid symptoms, interfering with nutrition and acting destructively on the cells. The term intoxication is applied when infectious microbes remain localized and only their toxic products enter the system. A certain bacterium may produce one or more toxins, toxalbumins or bacterioproteins (tuberculin). They are generally destroyed by heat, light, and air, and by prolonged keeping (attenuation). They may be soluble (tetanus, diphtheria) or insoluble (endotoxins of B. typhosus, cholera spirilla, and pyogenic cocci), and present only in the bodies of the bacteria. The filtrate of diphtheria bacilli cultures is poisonous (soluble toxin); that of typhoid cultures is harmless. The tetanus bacillus is responsible for four distinct toxalbumins or toxins: tetanin, tetanospasmin, tetanolysin, and one unnamed. The relative toxicity of toxins in general is enormous; the diphtheritic toxin can produce lethal results in a living being 20,000,000 times its own weight. Tetanus toxin is 300 times as toxic as strychnin. The incubation period of an infectious disease is the period during which sufficient toxins are being formed to produce an appreciable constitutional effect.

When diphtheria toxin, prepared from virulent cultures, is injected into a susceptible animal, as the horse, in gradually increasing doses (usually triweekly for from 6 to 12 months), the said animal acquires a marked tolerance to the poison, so that an amount can finally be injected which at first would have proved quickly fatal. The serum of the animal's blood also acquires the property of protecting other animals against diphtheria when injected subcutaneously in sufficient dose. Such serum when concentrated is known as antitoxin (phylaxin), and is standardized by physiologic tests against a given quantity of toxin: both being injected at the same time into guinea-pigs. The amount of antitoxin produced may be 100,000 times that of the toxin injected. Sera are now put up in a dry and permanent form, as well as liquid. A normal antitoxic unit will counteract 100 doses of toxin fatal to the guinea-pig.

The test-dose of Ehrlich is the amount of filtrate which is just sufficient to kill the animal in four days when mixed with a whole unit of serum. Ehrlich's phenomenon is the diminution of toxic action by successive additions of equal quantities of antitoxin, such effect gradually diminishing. It may be accounted for by incomplete reaction, as between acetic acid and alcohol, or, perhaps better, by selective absorption of one colloid by another.

Anaphylaxis (allergie = altered energy) is the term applied to the supersusceptibility or supersensitiveness of the system induced to a serum by the injection at a certain previous interval (10 to 12 days for horse serum) of the same serum. This fact perhaps accounts for the phenomena hitherto explained by the supposed endotoxins, the period of incubation and some points concerned with heredity. The specific antibody (allergin) of sensitization (first step toward immunity) can be transferred passively from one subject to another. Rennin, trypsin, diastase, and other enzymes excite the formation of antagonistic antibodies. These in turn, when injected in an active state into new animals, bring about the formation of still other antibodies.

Immunity (McFarland) is the protective reaction manifested by living beings toward infections and toxic agents. According to the Ehrlich theory of immunity, the presence of toxins in the blood stimulates the protoplasm of the leucocytes and the fixed tissues to an intramolecular migration of atoms to a more stable position. In this change are thrown out certain side-chains, or receptors (haptins), which correspond to the unsaturated radicals of a complex molecule serving as hooklets to combine with the haptophore groups of certain food molecules, and which have a particular affinity for the haptophore group of the given toxin and combine with and neutralize it, toxophore group and all. The molecules are not broken apart if the stimulation is slight, but protoplasmic resistance to the toxins is increased, as exemplified by vaccination, which is indeed a modified attenuated form of variola. Under increased stimulus by the toxins myriads of these side-chains are liberated into the serum, giving it antitoxic properties, and constituting the more or less perfect active artificial immunity observed after one attack of a contagious disease. It is claimed that the amount of antitoxin set free can be augmented by the administration of agents (pilocarpin) which stimulate cell-activity. Antitoxins may also be formed by the stimulating action of non-bacterial proteins (ricin, abrin).

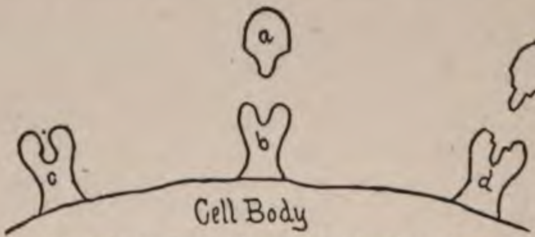


Fig. 69.—Diagram Illustrating Ehrlich's Theory.

If, on the other hand, as in malignant cases, the toxin is overwhelming in force and amount, reaction is paralyzed, no side-chains are evolved, and the patient quickly succumbs. Passive immunity is that conferred by the injection of antitoxins (diphtheria, tetanus, antistreptococcic, etc.), and is of much shorter duration (3 weeks or less with diphtheria) than active immunity, since it is not re-enforced by fresh supplies from the cells and is gradually eliminated. In natural immunity there is no attraction between receptors and toxins. Relative immunity depends on a relatively small number of haptophores.

The more or less specific affinities shown by toxic substances (strychnin and tetanus toxin, motor nerve cells; diphtheria.

peripheral nerves; venoms, respiratory center and blood-corpuscles) depend on the power of haptophorous molecules to combine with certain cells having appropriate receptors. Any gradual progressive intoxication produces immunity, as with the morphin habit or in arsenic eaters (antiarsenin in the blood). Receptors are in part permanent; in part variable by generation and regeneration, unless the cell is killed.

Toxins act as localizers or condensers, with concentration in particular cells similar to the action of picric acid when wool is immersed in a dilute solution. There is great susceptibility when toxophilic receptors are limited to vital organs; slight susceptibility when there is a wide distribution of these receptors in indifferent tissues; insusceptibility either because rarely toxophore groups do not act on protoplasm, or frequently through lack of toxophore receptors. Erythrocytes possess very many and varied receptors, and play an important rôle in metabolism in storing intermediate bodies. The toxoids of Ehrlich are attenuated toxins, still capable of uniting with the functionating part of the cells of the human body. A toxin having a greater affinity for the cells than the antitoxin is termed a protoxin; one with as much affinity, a syntoxin (deuterotoxin); one with less affinity, an epitoxin. Toxoids are similarly classified, epitoxoids being known as toxons. Toxins are further divided into an alpha and a beta portion, depending on the ease with which they are changed into toxoids.

Antitoxins are stable products not affected by atmospheric changes or natural heat or light. They do not dialyze as do the soluble toxins. Their antitoxic strength is destroyed in the alimentary canal, by the pancreatic secretion particularly. The frequent injection of immune serums leads to the formation in the body of counteracting anti-immune serums.

The destruction of micro-organisms and their toxins (Sajous) is insured by an adequate febrile process, due to interaction of *trypsin* (active in digestive vacuoles of leucocytes and in blood-stream), fibrinogen (nucleoproteid rich in P, secreted by neutrophile leucocytes), and adrenoxin (oxidizing secretion of adrenals). This interaction produces sufficient heat energy (fever) to enhance the efficiency of trypsin, and takes place normally in the peripheral capillaries, where surplus heat energy can be liberated most easily. This defensive action is favored artificially by the hyperemic methods (cupping, proximal bandage, etc.) revived by Bier.

The body also defends itself, according to Metchnikoff, by phagocytosis, the enzyme microcytase in the leucocytes (microphages; acute infections) and larger cells (macrophages; large lymphocytes; chronic diseases) digesting ingested bacteria, which exhibit in relation to the body cells attractive and repellent affinities (positive and negative chemotaxis). Microphages destroy bacteria; macrophages, blood-corpuscles, tissue remnants, and other large bodies.

The germicidal action of the blood is ascribed to soluble nucleins (alkalies render more soluble), derived from the leucocytes, and termed variously alexins, sozins, or defensive proteids. The opsonins of the blood modify bacteria so as to render them a ready prey to the phagocytes. Opsonins change bacteria and other cells so that these by chemic or electric (possibly also mechanic) means diminish the surface tension of leucocytes, and thus bring about phagocytosis by substituting positive for negative chemotaxis.

These opsonins are not identic with antibodies, but are relatively simple, probably allied to enzymes and are destroyed by heat. The opsonic index is the average ratio of the number of bacteria taken up by leucocytes in a given patient as compared with the same finding in the blood of a healthy person. In the vaccine treatment (revived by Wright) of various infectious diseases somatic self-defense is stimulated by the injection of a few to many millions of dead cocci or bacilli.

In the phagolysis of irritation or inflammation enzymes are liberated into the body humors. Relapses in infectious diseases and the increase of virulence seen in bacteria frequently passed through the bodies of animals (Welch), may depend upon immunization of bacteria against the defensive products of the human body. Mother's milk appears to contain immunizing substances, so that nursing infants rarely acquire infectious diseases from their mothers.

Snake-venoms belong to the class of toxalbumins, and the protective and curative action of antivenene is probably a biochemic reaction analogous to that of antitoxins. It is a curious fact that venom when taken by the stomach protects against snake-bites, and the same is true of antivenene, but antitoxins are ordinarily best given hypodermically. Vaughan believes that toxins and antitoxins are nucleins, neutralizing each other chemically.

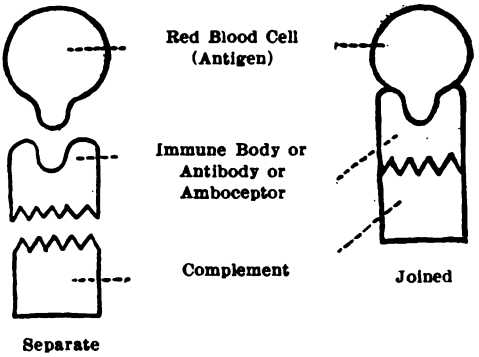
Chemically speaking, tubercle bacilli consist of protoplasm inclosed within a waxy capsule. The toxic products of the life-processes of tubercle bacilli include a systemic poison (vasodilator), a fever-producing agent, and a necrotic. Tuberculin (the old T. O., not T. R.) is a 4 to 7 per cent. glycerin extract prepared from old, concentrated culture-media of tubercle bacilli. It contains salts, a nucleoproteid, and other undefined proteins, one of which (albumose) is a fever-producing toxin, and is used for diagnostic purposes in the dose of ½ or 1 mg.

The P-content of tubercle bacilli varies with the amount of fat or wax (10 to 40 per cent.). The residue from extracted bacilli is mainly chitin (like keratin). They also yield 9 per cent. of nucleic, or "tuberculinic," acid, which appears to be the active ingredient. The almond odor of cultures is due to volatile fatty acid. Tuberculous disease spreads most rapidly when the patient is wasting, and so passing an excess of fat into the blood.

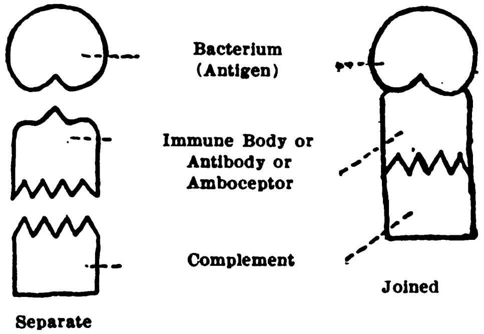
HEMOLYSINS.

It has been discovered that the serum of one animal injected with the blood of another becomes toxic for the animal

Hemolytic System.



Bacteriolytic System.



Illustrating Hemolysis and Bacteriolysis. (*Pershing.*)

whose blood was injected, agglutinating and dissolving the red corpuscles of the blood. Such toxic substances (probably produced by macrophages), when produced by the injection of heterologous blood, are termed heterolysins. When the injections are in the same species isolysins are formed. The absorption of exudates may depend on the property of isolysis. Autolysins have so far not been produced. The serum of many animals is naturally cytotoxic and hemolytic, and the same is true of snake-venoms. Repeated injections in increasing dosage lead to the devolopment of an antitoxic resistance to the poisons. Certain toxins (tetanolysin, staphylolysin) contain two sets of molecules, one binding the antitoxins (haptophorous) and one producing hemolysis (toxophorous). Leucocytolysins are similar in action to hemolysins, dissolving the white blood-cells, however, without previous agglutination. Various theories of cytolysis have been proposed. One is that in immune serums there are two distinct substances, namely: the specific immune body (amboceptor, intermediate body, desmon, fixateur, substance sensibilisatrice), which is not destroyed by heat; and the non-specific alexin or complement (lysin, addiment, cytase, end-body), which is destroyed at 50° to 60° and which exists preformed in all blood.

The latter is destructive to the cells, while the former, being an amboceptor, serves as an intermediary fixing agent or mordant. The complementary body is the real hemolytic agent. It is bound by the specific immune or intermediary body to the corpuscles.

The complement (perhaps lecithin) consists of zymophore and haptophore; the amboceptor, of complementophile and cytophile.

Anticytotoxins is the term applied to substances that neutralize hemolytic serums. They are produced, in a similar way to antitoxins, by injecting hemolytic serums in increasing doses into susceptible animals.

Antibodies (anticytolytic or anti-immune) prevent (1) the linking of the immune body to the cell receptor, or (2) of the alexin to the immune body. Like antitoxins, they are uniceptors. Certain animals are provided constantly by Nature with antihemolysins. Cancerous secretions have a hemolytic effect.

The Wassermann syphilis reaction depends on the prevention of laking in sensitized red blood-corpuscles (when complement is added) through fixation of complement by the combined action of extract of the liver of syphilitic infants (antigen) and the blood-serum from the syphilitic patient (antibody). In the Noguchi modification human red blood-cells are used as an indicator (instead of sheep's cells), along with the corresponding immune body.

BACTERIOLYSINS.

Bacteriolysins are complex substances composed of a peptonizing ferment and a bacterial derivative. They have a digestive and antibacterial action, but no effect on toxins, which they set free, sometimes aggravating the condition.

Destruction of bacteria may be due to plasmolysis or plasmoptysis (spewing out of cell-contents), depending on osmotic disturbances. Thus the diplococcoid form of colon bacilli said to be found in cirrhotic livers and the accompanying ascitic fluid are perhaps degenerating forms due to plasmolysis. These dead bacilli and bacillary fragments tend to take up iron, forming pigment-granules. Bacteriolysins may further be produced by the digestion of bacteria with peptonizing ferments. These lysins are pptd. by acetic acid and dissolve again in alkaline water. Blood-serum appears to contain a multiplicity of bacterial complements. Mother's milk is relatively rich in bacteriolysins.

Various other toxic and antitoxic substances—such as epitheliolysin (trichotoxin), spermotoxin, and nephrolytic serum—are developed by the natural resistance of the cells to outside influences. It is possible that in some cases sterility depends on the presence of spermotoxic substances in woman's blood.

AGGLUTINATION.

This curious property, forming the basis of the Widal test for typhoid fever, appears to be due to the action of agglutinins of unknown origin, so changing the bacterial membrane as to render it sticky. The agglutinating property of serum is not destroyed by heating to 80°. A dilution of the serum, 1:50 or higher, is practised in diagnostic work. This agglutinative power may persist for years after the attack. Agglutinins contain a combination (haptophore) and a functional (agglutinophore) group. They are soluble compounds related to globulins.

The injection of protein substances into the blood of an animal causes its serum to develop a precipitin, or specific precipitating substance, for the liquid injected. When typhoid cultures are mixed with the blood-serum of a typhoid patient, a non-bacterial ppt. is formed and quickly settles (macroscopic test). Antitoxic sera have the same effect. Normal serum contains agglutinins which are not specific. Agglutination may be produced by closely related bacteria, but to a much less degree. It is also caused by chemic agents and by the metabolic products of the bacteria themselves, occurring spontaneously in cultures.

The agglutination of blood-corpuscles in coagulation is most marked in pneumonia, rheumatism, erysipelas, and typhoid. Owing to the firmness of the clot in these cases, the buffy coat is unusually distinct. Despite the great mass of conjecture and assumption incorporated in the modern theories of infection and immunity, the heuristic value of these hypotheses is manifest and unquestioned.

QUESTIONS ON PHYSIOLOGIC AND PATHOLOGIC CHEMISTRY.

1. Why is saliva frothy and viscid?

2. What is the color of the stools in jaundice?

3. How detect starch in feces? Fat? Mucus? Casein?

4. Why does the sweat often smell sour in summer?

5. Explain chemically the peculiar appearance of the skin in cachexias and starvation.

6. What effect does muscular exertion have on the alkalinity of the blood?

7. How does $(NH_4)_2C_2O_4$, added to freshly drawn blood, prevent its coagulation?

8. Why does a sip of vinegar cause pain in mumps?

9. What causes the film on the surface of saliva on standing?

10. How does deficient motility interfere with stomach-digestion?

11. Why not feed a young baby crackers?

12. Why do we need to add salt to our food?

13. How detect with certainty the presence of saliva in the stomach-contents?

14. Why is whole-wheat bread more nutritious and less digestible than white bread?

15. Why are sterilized milk and artificial infant-foods likely to produce rickets and scurvy?

16. Why is it best to boil potatoes in their skins?

17. What kind of diet is best for hypochlorhydria?

18. Why is toast more digestible than untoasted bread?

19. Why must the blood be saline? Alkaline?

20. What chemic effects have fruits on blood and urine?

21. Explain the chemistry of infantile colic.

22. What chemic compounds are present in hair?

23. Why do the nursing mother's teeth often decay rapidly?

24. Write formulas for xanthin, theobromin, caffein (thein), and uric acid.

25. Gall-stones are most frequent in fat, elderly women. Why?

26. To reduce obesity what kinds of food should be avoided?

27. Why is fracture in children often of the "green stick" type?

28. What chemic changes accompany muscular contractions?

29. What is the chemistry of atheroma?

30. What is the difference in composition between blood-serum and plasma?

31. What element is indicated medicinally in anemic conditions?

32. What is the color of a person's lips poisoned by "blowing out the gas"?

33. Explain the symptoms of "heart-burn" and "water-brash."

34. Why do milk and other proteid foods give relief in hyperchlorhydria?

35. State the chemic distinctions between gastric ulcer and gastric cancer.

36. What hydrocarbon is found in the body? What alcohol? What ethers?

37. Compare the composition of human and bovine milk.

38. What are the chemic differences between whey and buttermilk?

39. How does chyle differ from lymph?

40. Give some chemic reasons for the symptoms of Addison's disease.

41. What effect has lime-water on the gastric digestion of milk?

42. How distinguish with certainty blood in the stools from other coloring matter?

43. Why is yellow sputum usually more liquid than white?

44. What are the chief distinctions between exudates and transudates?

45. How do potatoes cure scurvy?

46. If 1 gm. urea = 3 gm. albumin, how much protein food does a laboring man weighing 140 pounds require daily?

47. What advantages have cheese and pulses over meats in uric acid cases?

48. Name ten foods especially good for students, and give reasons.

49. Define internal respiration.

50. What substances act as fuel foods?

51. What is the office, chemically speaking, of digestion?

52. Why is it sometimes advisable to prescribe medicines with ginger, capsicum, nutmeg, and other spices?

53. Explain from the physic standpoint the removal of dropsies by diuretics.

54. How may an attack of uremia be pptd. by the free use of digitalis after tapping an ascites?

55. Distinguish between active immunity, passive immunity, vaccination, and natural immunity.

56. Why do fats generate more heat in the body than carbohydrates or proteins?

57. Why is the lowest daily range of normal body-temperature in the early morning?

58. Make out a diet-table for 3500 calories, using roast beef, wheat bread, potatoes, milk and butter.

59. Why should diphtheria antitoxin be given as early as possible?

60. How does the addition of borax or Na_2CO_3 delay the souring of milk?

61. Why do infants become anemic when limited too long to a milk diet?

62. Explain chemically the curative action of gelatin in purpura and intestinal hemorrhages.

63. What effect does the diet have on the quantity of feces, and why?

64. How does muscular exercise benefit goutiness?

65. How does breathing cold air predispose to coughs and colds?

66. Why does the face turn bluish during a hard fit of coughing?

67. Why does salt or sugar make one thirsty?

68. Why is much meat bad for young children?

69. How does eating candy affect the teeth?

70. Why, chemically speaking, do we shiver when cold?

71. Why do summer freckles occur mostly in blond persons?

72. How does a hot bath relieve fatigue following muscular exertion?

73. Why is the administration of calomel followed by spinach-like stools?

74. Why is milk specially valuable in nephritis?

75. Why is lactic acid always present with pyloric cancer, but sometimes absent with cancer of the cardiac orifice?

76. What acids collect at the anode in electrolysis of the human body?

77. Why are hypodermic injections slow to act in dropsic conditions?

78. Why do milk and meat not digest well together?

79. What effect does the melting of butter have on its digestibility?

80. What would a persistent ammoniacal discharge from vagina or rectum probably indicate?

81. How may either hypo- or hyper-chlorhydria favor the formation of excess of CO_2 in the stomach?

82. What are "liver spots"?

83. What is the specific remedy for myxedema?

84. On what kind of diet and for how long before making the test

should a patient be placed previous to the Weber test for occult blood in the stools?

85. What factors favor and which retard the curdling of milk?

86. Given a scanty breast milk with 1.2 per cent. fat, 0.9 per cent. albumin and globulin, 1.3 per cent. casein and 6.4 per cent. lactose, what advice would you give the mother?

87. Why are hot fats irritant to the stomach?

88. Why is CO_2 diminished in the blood in acid intoxications?

89. How could you prove the presence of potassium phosphate in a meat extract?

90. Compare the weight of the hemoglobin molecule with that of H.

91. How does sodium citrate prevent the coagulation of milk by rennin?

92. Ethyl alcohol can always be demonstrated in the contents of the small intestine. Explain.

93. How do toxic amounts of mineral acids affect internal respiration?

94. How could you determine by spectrum analysis that a person had died from CO poisoning?

95. What liquid is present in the serous cavities of the body?

96. Why does lymph become more opaque during the process of digestion?

97. Why do herbivorous animals accumulate albumins better than do the carnivora?

98. Why is the liver of animals sweeter after some time than just following death?

99. How do acids aid the curdling of milk?

100. Why are milk and eggs specially good foods for children?

101. What causes the "coffee ground" appearance of the vomit in cancer of the stomach?

102. How is a dechlorinated diet of benefit in Bright's disease?

103. How does $NaHCO_3$ act as an antidote in diabetic coma?

104. Why may the blood remain fluid after death from oxalic acid poisoning?

105. What class of foods is lacking in eggs?

106. Why does deficiency in hemoglobin cause dyspnea?

107. What indication can be drawn from colorless stools becoming normal brown on treating with ether?

108. Which has more Ca, milk or lime-water?

109. Why are sweets and fats contraindicated in lithemia?

110. Why is one more thirsty after eating meats than carbohydrates?

111. Why is the electric resistance of the skin greatly diminished in exophthalmic goiter?

112. Explain chemically the sallow color of chronic malaria.

113. Write equation for reaction which takes place in the stomach when $NaHCO_3$ is administered as an antacid in gastric ulcer.

114. Should the chest be oiled in cold weather if one is going to be out of doors?

115. Why are turnips preferable to carrots for diabetic patients?

CLINIC CHEMISTRY.

GASTRIC JUICE.

FOR clinic purposes the stomach-contents are usually drawn with the soft stomach-tube an hour after taking Ewald's test-breakfast. This consists of a one-ounce dry roll or two pieces of toast without butter, and 300 c.c. (500 c.c. better) of warm water or weak tea without milk or sugar. Boas's test-breakfast consists of one ounce rolled oats (no lactic acid) in a quart of water, boiled down to a pint and salted to taste. The double test-meal of Hemmeter consists of a full meal at 8 A.M.; Ewald's test-meal at 12 M.; withdrawal of stomach-contents and examination at 1 P.M. Disappearance of the entire breakfast points to normal digestion; absence of all proteids, with presence of considerable carbohydrates = hyperchlorhydria; absence of all carbohydrates, with presence of some beef and egg = hypochlorhydria or anacidity; presence of entire meal, with the milk perhaps all uncurdled = achlorhydria and absence of ferments and glandular atrophy. The gastric contents after settling usually show a ratio of solids to liquids 1:3 or 1:4. Above ⅓ (to ½) indicates deficient secretion or lack of motility. Under ¼ (to ⅒) is probably due to increased secretion.

The quantity of gastric juice obtained in this way is normally about 40 c.c.; more than 60 c.c. or less than 20 c.c. is pathologic. The former condition points to dilation and motor insufficiency; the latter, to too rapid emptying of the viscus. The liquid should be filtered at once and examined as soon as possible.

The reaction is tested with litmus-paper, and is normally frankly acid. The presence of free acids is shown by congo-red paper, which turns sky-blue with 1 part in 50,000 of mineral acid; violet, with organic acids. Acid salts (phosphates) have no effect on this indicator. Tropeolin 00 in aqueous solution is a dark yellow-red or brown fluid, changed to pink by 1 to 4000 of free HCl, giving a bluish residue on drying; to a straw color by acid salts. Benzopurpurin (6 B) paper is turned an intense dark brown by mineral acids. A 1 to 2000 aqueous methyl-violet solution added to the specimen yields a copper-blue color with HCl; a violet-blue with organic acids.

Free HCl can also be shown by the addition of 3 or 4 drops of a 0.5 per cent. alcoholic solution of dimethylamidoazobenzol, which gives a pink color if this acid is present in the free state (shows 0.07 per cent.), while a yellow color indicates its absence.

The dimethylamidoazobenzol test is unreliable, according to Hemmeter, only when there is no free HCl present. Günzburg's reagent shows 0.05 per mille and is prepared by dissolving 1 gm. vanillin and 2 gm. phloroglucin in 100 c.c. of alcohol (best kept separate, as the mixed solution tends to turn brownish-red). The solution to be tested is placed in an evaporating dish, 2 or 3 drops of the reagent added, and the mixture evaporated to dryness just below the b.p. on the water-bath or over a small flame. A purple or pink-red color shows free HCl. Boas's reagent is prepared by dissolving 3 gm. of cane-sugar, 10 gm. of resorcin, and 3 c.c. of alcohol in 100 c.c. of distilled water. To the specimen in a porcelain dish add 2 or 3 drops of the reagent and evaporate as above, getting with free HCl a vermilion line at the edge of the dried fluid, fading to reddish-brown on cooling.

Uffelmann's reagent for lactic acid is prepared by adding a drop of dilute neutral $FeCl_3$ to 10 c.c. of 2.5 per cent. carbolic acid solution. It reacts to 3 parts in 10,000 of the acid or its salts. The resulting amethyst color is discharged by mineral acids, but lactic acid changes it to a straw color (butyric brownish), best noted by comparing with another tube containing the same amount of iron in the same volume of water. The reaction is interfered with by much free HCl (dilute with H_2O) or acid phosphates, and by the presence of cane-sugar or alcohol. It sometimes gives a brownish color (sulphocyanate) when a large amount of saliva is intermixed. Bile-stained juice also may simulate the color of this test. To make the test positive the lactic acid must be isolated by extracting several times with ether, which is distilled off and the residue dissolved in water for testing. Gastric juice containing more than a trace of lactic acid has a distinct sour-milk odor.

Acetic and butyric acids are recognized by their distinctive odors. Acetic acid also gives a red ppt. with dilute $FeCl_3$; butyric, a tawny red, in amounts of 0.5 per mille. Free fatty acids in the filtrate on warming turn wet blue litmus-paper red when held in the mouth of the tube.

Test for Butyric Acid (Austin).—To ethereal extract in water add a granule or two of $CaCl_2$. The butyrate of Ca forms, rising to the top of the liquid as oily drops which have a strong odor of rancid butter and show fine, needle-like crystals if allowed to evaporate.

Alcohol, rarely present from yeast-fermentation, is detected by its odor or by the iodoform test. Acetone and aldehyd may also be present.

Estimation of Pepsin (Hammerschlag).—Take two test-tubes, each containing 10 c.c. of 1 per cent. solution of egg-albumin, to which HCl (4 p.m.) is added. Add to one tube 5 c.c. of gastric filtrate; to other 5 c.c. of distilled water. Place both tubes in the incubator at 37.5° for an hour, and then test for amount of albumin in each tube with Esbach's fluid and centrifuge. The peptic power (normally 80 to 90 per cent.) is represented by the proportion of albumin thus digested.

Test for Rennin.—Dilute filtrate to 1: 10, 1: 20, 1: 40 and 1: 80. Add to each 5 c.c. dilution 5 c.c. of cooked and cooled milk and a drop of $CaCl_2$ solution. Place specimen in brood oven for 20 to 30 minutes. If rennin is normal the 1: 20, 1: 40 and 1: 80 and often 1: 160 dilution coagulates; if much diminished, only 1: 10 will curdle.

The products of starch digestion are tested for by placing a few drops of the filtered gastric juice in a porcelain dish, and adding a drop of Lugol's solution. Normally this yields a reddish-violet (amylodextrin) or brownish-red (erythrodextrin) color. Absence of coloration (achroodextrin) shows marked reduction of HCl. Under the microscope most of the starch-grains should have lost their characteristic cellular rings. Albumose and peptons are demonstrated in the gastric filtrate with the biuret test, after removal of albumins by boiling.

Microscopic Findings in the Gastric Contents.—Staphylococci in abundance are found in connection with carcinoma ventriculi. A small Gram-negative ammonia-producing bacillus is present in euchlorhydria and hyperchlorhydria. There are always a few columnar cells in the stomach contents; also squamous epithelia (oral and pharyngeal). Many columnar cells accompany gastritis. Nasopharyngeal mucus occurs in yellowish clumps, often containing dust-particles. Mucus is in excess in acute and mucous forms of gastritis. The mucus in gastric contents from saliva is lighter and floats; that from the stomach walls is at the bottom of the cylinder, closely mixed with food particles. The constant occurrence of pus in the gastric contents is diagnostic of carcinoma, according to most authorities. It is occasionally present from being swallowed, from the rupture of pus foci, or from gastritis following burns or corrosion of the stomach. Free nuclei differ from pus cells (which they resemble) in showing no nuclei on addition of acetic acid. Blood from the stomach is usually dark red (fluid and clumpy) in ulcer; more like a coffee-stain in cancer. The cells are seldom demonstrable under the microscope in cancer, and not always in ulcer. Blood-stained mucus is not seldom observed after the passage of the tube when there is much straining, particularly in atrophic states.

The long, non-motile, club-shaped Oppler-Boas chain bacilli are present in large numbers in gastric cancer, but are not pathognomonic, being merely evidence of deficient HCl. Yeast-cells and sarcinæ are usually found in fermentive conditions (non-malignant ectasis and chronic catarrh). Shreds of membrane may appear in the vomit of phlegmonous gastritis, and pieces of the superficial mucosa in the siphoned contents of the stomach in simple chronic gastritis. Cancer "pearls" are very rarely found in the debris brought up in the eye of the tube during sounding.

PRACTICAL QUANTITATIVE ANALYSIS OF GASTRIC JUICE.

In Toepfer's method four reagents are required: 1. Decinormal NaHO. 2. A 1 per cent. alcoholic solution of phenolphthalein, to indicate total acidity. 3. A 1 per cent. aqueous solution of sodium-alizarin sulphonate, to indicate all acids except loosely combined HCl. 4. A 0.5 per cent. alcoholic solution of dimethylamidoazobenzol, to indicate free HCl only.

Put 10 c.c. of filtered gastric juice into each of three beakers. To the first add 1 or 2 drops of phenolphthalein; then run in the decinormal solution till a deep-red color is produced which no longer increases in intensity (albumose-peptons act as acids upon phenolphthalein). To the second add 3 or 4 drops of the alizarin solution, and titrate with the decinormal alkali till the first pure violet color is reached. To the third beaker add 3 or 4 drops of dimethylamidoazobenzol, and if a red color is produced run in the decinormal alkali till the red just disappears and the fluid becomes yellow.

The number of c.c. required for the first beaker *(a)* represents the total acidity; for the second beaker *(b)*, all acids except loosely combined HCl. Hence, deducting *b* from *a* leaves the combined HCl. The number of c.c. needed to change the color in the third beaker *(c)* represents free HCl. Hence, deducting *c* from *b* leaves the organic acids: chiefly or wholly lactic. If organic acids are absent, *(b)-(c)* represents the acid salts.

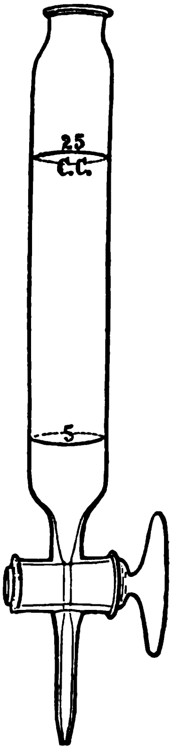
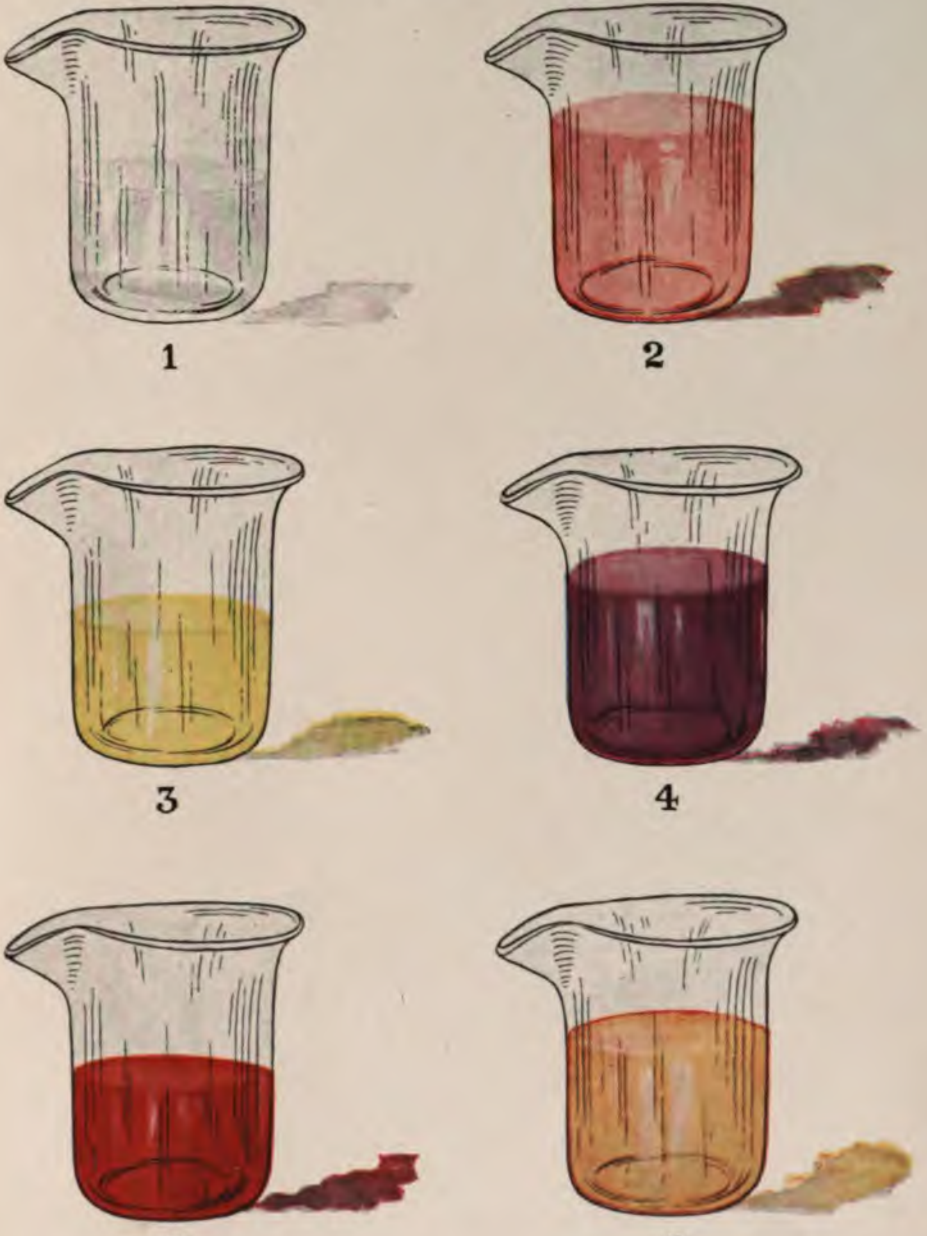


Fig. 70.—Strauss's Separating Funnel for Lactic Acid Test. (*Lenhartz.*)

The amount in grams of each of these five findings, reckoned as HCl, is obtained by multiplying the number of c.c. required in each instance by the factor 0.003637 (no. of c.c. of lactic acid by 0.009); or the percentage (when 10 c.c. of juice are used) is found by multiplying by 0.03637. The quantity of each constituent is frequently expressed as parts per 100 c.c. Thus, if 5 c.c. of gastric juice require 6.4 c.c. of $n/_{10}$ NaOH to neutralize it, the total acidity is 20 × 6.4, or 128. Total acidity is increased up to 120 in hyperemic conditions (ulcer, neurosis, early acute inflammation); it is below 50 in chronic gastritis, advanced carcinoma, pernicious anemia, and occasionally in neuroses. The stomach-contents may be neutral or alkaline in achylia gastrica (often of hepatic origin) and atrophic or mucous gastritis, or with much saliva. Fluctuating amounts of free HCl point strongly to a neurosis. The most common abnormal condition is functional hypochlorhydria with organic acid fermentation. This condition may be idiopathic (dietetic), but is often secondary to other affections, as chlorosis, and pulmonary, cardiac, renal and hepatic diseases. HCl also varies largely with the amount of water in the system.

Quantitative Test for Lactic Acid (Strauss).—A separating funnel graduated to 5 c.c. below and 25 c.c. above is filled to the lower mark with gastric juice, and ether is added to the upper mark. The funnel is corked, well shaken, allowed to stand till the fluids separate, and the liquids allowed to run out to the lower mark. Distilled water is now

PLATE VII.



ANALYSIS OF GASTRIC CONTENTS.

The beakers with odd numbers show the filtered gastric juice with indicator added, before titrating with decinormal sodium hydroxid; the even-numbered beakers show the colors obtained by neutralizing with the alkali. In figures 1 and 2 phenol-phthalein is used as an indicator; sodium-alizarin sulphonate, in figures 3 and 4; dimethyl-amido-azobenzol, in figures 5 and 6.

added to the upper mark, and the mixture treated with 2 drops of a 1 to 10 solution of tincture of chlorid of iron. On shaking the mixture an intense-green color is produced if lactic acid is present to the extent of 1 to 1000 or more; pale green if between 0.5 and 1 per 1000.

Test for Gastric Absorption.—Let the patient take a capsule containing 5 grains of KI along with 100 c.c. of water on an empty stomach. The salt should be found in the saliva within 15 minutes, as shown by means of starch-paper wet with saliva, then touched with a drop of HNO_2. Free I is liberated, giving with the starch a blue color. The absorptive function is impaired in all gastric diseases, particularly carcinoma and dilation.

Test for Gastric Motility.—1. The oldest and most reliable method is that of Leube, which consists in washing out the stomach 6 to 7 hours after a full meal of meat, soup, and bread, or 2½ hours after Ewald's test-breakfast. Any residue found at this time denotes a lack of motor power.

2. Let patient take 10 grains of salol in capsules. The salol is broken up in the intestines and should appear in 40 to 75 minutes in the urine as salicyluric acid, as proved by filter-paper dipped in 10 per cent. $FeCl_3$ solution giving a blue spot with a drop of the urine. If the reaction comes later than the time mentioned or if it lasts 30 hours or longer, the motile power is deficient. It must be borne in mind that salol is rarely decomposed very early in the stomach itself, owing to an alkaline mucous gastritis.

3. Another method (Klemperer's) of estimating the motor function of the stomach is to wash the viscus thoroughly and then pour through the tube 100 c.c. of olive-oil, removing what remains 2 hours later by aspiration, at which time the residue should not exceed 20 to 40 c.c.

The motor power of the stomach and intestines is fully equal in importance to the secretory functions. Insufficient motility checks digestion and leads to fermentation and autointoxication.

The presence of food in the fasting stomach before breakfast indicates a high degree of submotility, usually accompanied by gastric dilation (gastritis or benign or malignant pyloric stenosis).

The form and location of the stomach is usually determined by palpation and percussion. For these maneuvers the organ should be distended with CO_2, generated by administering, each in 250 c.c. of water, a teaspoonful of tartaric acid followed by the same quantity of sodium bicarbonate. This procedure is also useful in palpating tumors. Another method is to give a glass of water, and by auscultatory percussion note lower (flat sound) border of stomach.

Transillumination of the stomach is rendered more effective (Kemp) by introducing into the empty stomach a solution containing ⅛ grain fluorescin and 15 grains $NaHCO_3$ to the pint of normal salt solution.

MILK.

Mothers' milk taken to be tested should be either a specimen from the whole breastful or a sample taken about midway in nursing. The milk, whether human or bovine, should be well mixed by shaking before the quantitative tests are applied. It ought to be as fresh as possible. The quantity for each test is best measured with a graduated pipet.

The reaction of milk is ascertained by means of both red and blue litmus-paper. Human milk is normally alkaline. Fresh cows' milk is amphoteric—acid (phosphates) to litmus, alkaline (carbonates) to turmeric. Its color and consistence should be carefully noted. The whiter and more opaque, the richer the milk is, unless adulterated.

The specific gravity may be determined by means of a cylinder and a correct hydrometer or Quevenne's lactodensimeter (reads from 15 to 40—prefix 1.0 for sp. gr.), or more accurately with the picnometer or the lactometer. This latter instrument is so graded that 0° on its scale represents a sp. gr. of 1,—that of water,—while 100° is equivalent to a sp. gr. of 1.029, the normal minimum of good milk, and 120° to 1.034. The sp. gr. is obtained by multiplying any degree on the scale by 0.29 and prefixing 1.0.

Genuine cows' milk usually ranges from 105° to 120°. Skim-milk is heavier. Watered milk is of low specific gravity: below 100° if sufficient water has been added. Natural rich Jersey milk is generally heavy. Any whole milk that stands above 1.033 is nearly certain to have been skimmed, while that below 1.029 is nearly always watered. In making corrections for temperature one hydrometer degree approximately may be subtracted for each 10° F. below the standard of the hydrometer, or one degree added for each 10° F. above this standard. The reading should be taken within a half minute after immersion. The milk should not be tested within three hours of leaving the cow.

The percentage of cream by volume is ascertained by means of the creamometer, which is simply a small cylinder graded in hundredths and kept closed with a glass stopper. The percentage of cream is quite variable as to the amount of fat, depending on dilution, agitation, temperature, and other factors. Specimens that contain the least fat may yield the most cream, and a milk that has been watered will in a few hours separate a thicker layer of cream than if it had not been watered. The amount of cream that separates in twenty-four hours is from 10 to 12 per cent. in ordinary and 15 to 20 per cent. in good milk. Less than 10 per cent. of cream with a sp. gr. above 1.033 denotes skimming. Less than 20 per cent. with a sp. gr. below 1.029 shows that the milk has been watered. The fat-content of cream is from one-third to one-half.

Determination of Total Solids.—Weigh into a tared platinum dish or watch-glass 5 c.c. of milk, evaporate on the water-bath to dryness (about three hours), then transfer to the water- or air-oven at 100° C. until it ceases to lose in weight (about three hours), cool in desiccator, and weigh.

Determination of Ash.—The mineral residue is estimated by careful ignition of the total residue at a dull-red heat until the organic matter is burned off and the sediment becomes gray-white in color and ceases to lose in weight. Adulteration with chalk, borax, etc., increases both the total solids and the ash (above 1 per cent.). Phosphates, chlorids, and sulphates may be separated by the ordinary tests.

Determination of Fat.—In the Werner-Schmid method 10 c.c. of milk are mixed with 10 c.c. of strong HCl in a long test-tube with a capacity of 50 c.c. The mixture is brought to a boil (till the liquid turns deep brown, but not black); then cooled, 30 c.c of ether added, and the tube corked and shaken well. As soon as the ether separates, a wash-bottle cork-stopper (lower end of exit tube with a short curve and opening just above the line of separation) is inserted and the ether blown off into a tared flask. Ten c.c. more of ether are added twice, and blown off as before. The ether is now distilled from the flask and the fat-residue dried in the water-oven and weighed.

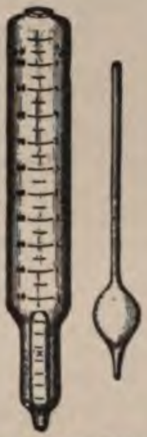


Fig. 71.—Feser's Lactoscope.

Another simple method of estimating the milk-fat is by treating the total solids with excess of benzin four times, boiling down on the water-bath each time to half, and decanting. The loss of weight in the residue equals the fat.

Since the opacity of milk varies with the amount of contained fat, pioscopic methods are of service in estimating this constituent. Feser's lactoscope consists of a glass cylinder constricted at the lower closed end, in the axis of which projects a small plug of white glass marked with a few horizontal black lines. Four c.c. of milk are introduced into the instrument, concealing the black lines. Pure water is then added, with frequent shaking, until the lines become visible. The surface-level of the liquid indicates the percentage of fat in the specimen, as shown by the graduation on the vessel. With a little experience the readings can be made accurate within 0.25 per cent. Opacity due to suspended chalk or starch is differentiated with the microscope.

The official method for detection of fat in milk is that of Adams. Ten c.c. of milk is absorbed by a coiled strip of fat-free bibulous paper, about 2 × 24 inches in size and tied with a thread or wire. This is dried on a watch-glass in the water-oven for an hour or more, and then placed in the middle chamber of a Soxhlet extractor. The tared flask (150 c.c.) at the bottom, containing 75 c.c. of ether, is heated cautiously on the water-bath. The ether-vapor, condensing in the upper part of the apparatus, flows back through the paper into the flask. After ten such siphon-washings, lasting one to one and one-half hours, the flask is detached and connected with a condenser and the ether distilled off. The fat-residue is dried in the air-oven at 100° to 105°, cooled, and weighed.

Babcock Test of Milk-fat.—Add to 17.6 c.c. of well-mixed milk or 18 c.c. of cream, about 17.5 c.c. of commercial H_2SO_4 (color at line of junction should be greenish); shake bottle gently, place in centrifuge, and whirl for five minutes; add boiling water to base of neck, and whirl a minute or two; again add boiling water, so that melted fat reaches nearly to top mark on scale, and whirl again one minute; before reading percentage of fat, pour some boiling water over outside of neck of bottles, to make sure that fat is melted.

Babcock Method for Determination of Fat in Human Milk.—Introduce 5 c.c. milk into special centrifuge tube, then an equal volume of strong H_2SO_4, and enough of a mixture of equal parts of amyl alcohol and conc. HCl to fill tube to neck. Centrifugate for five minutes. Pour in hot water till fat rises to neck, then rotate two minutes more, add more hot water until fat layer is within scale; rotate one minute more and read percentage directly.

Estimation of Proteids.—Casein can be pptd. by diluting 10 c.c. of milk with 50 c.c. of water, warming on the water-bath to 40°, adding 2.5 c.c. of 10 per cent. alum solution, and stirring thoroughly. After fifteen minutes the finely flocculent ppt. should be removed by filtration, washed, and determined by the Kjeldahl method for N (see "Urine"), the result being multiplied by 6.37 to obtain the weight of casein. To the filtrate from the alum ppt. add 10 c.c. of Almén's tannin solution (10 gm. of tannin, 10 c.c. of 25 per cent. acetic acid, 90 c.c. of alcohol, and 100 c.c. of water). This ppts. albumin and globulin, which may be estimated in just the same way as casein. The total N can also be estimated by placing 10 c.c. of milk in a Kjeldahl flask, adding 15 c.c. of H_2SO_4, and testing as above.

These proteins are often determined by difference. They may also be pptd. with tannin. The ppt. is dried and washed with 1 part of alcohol and 3 parts of ether till the washings show no trace of tannin with iron solution, then dried and weighed.

Austin's Centrifugal Method for Estimating Proteins in Milk.—Place 5 c.c. of milk in a graduate and dilute with water to 25 c.c., mix well and fill a graduated sedimentation tube to 5 c.c. with this dilute milk, and to 15 c.c. with Esbach's solution (see under "Urine"); the whole is then to be centrifuged for 3 minutes. The amount of ppt. in c.c. $\times$ 5 $\div$ 2 (for fat) $=$ percentage of whole protein content. To make a separate determination of casein and of lactalbumin and globulin, dilute 5 c.c. of milk to 50 c.c. with distilled water, and add cautiously 10 per cent. acetic acid until a ppt. begins to form, then pass CO_2 through for 15 minutes. Filter out casein, and divide filtrate into two equal parts: one is concentrated to less than 5 c.c. over a water bath at 60° (so that coagulation does not take place), washed into a graduated sedimentation tube with a drop or two of water, the tube then filled to 5 c.c., and the quantity found as before for total proteins, regarding each tenth of the tube as $\frac{1}{50}$ of 1 per cent. This multiplied by 2 gives albumin and globulin, and subtracted from total proteins leaves casein. The other half may be used for the sugar estimation, after removing albumin by boiling with a tiny portion of dilute acetic acid. The amount of sugar necessary to decolorize 10 c.c. of diluted Fehling's solution $= 0.067$ gram.

Another method for estimating sugar of milk is to acidulate with HCl, boil, filter, wash, and then boil filtrate again for an hour or so to hydrolyze all the lactose to glucose, which may then be estimated with Purdy's solution.

Short Methods.—A number of formulas have been devised by experiment to save time and trouble in milk analysis. When any two of the three data, sp. gr. (G), fat (F), and total solids (T) are known, the third can be calculated by the following formulas:—

$$T = \frac{F + 0.2186\ G\ \text{(last two figures)}}{0.859}$$

$$F = 0.859\ T - 0.2186\ G\ \text{(last two figures)}$$

For poor skim-milk, when $\frac{G}{T}$ exceeds 2.5, this modified formula should be employed:—

$$F = 0.859\ T - 0.2186\ G - 0.05\left(\frac{G}{T} - 2.5\right)$$

The following is a formula to determine the amount of skimming:—
S (solids not fat) — F x $\frac{3}{5}$ = x, or amount of fat removed.

The degree of watering is estimated by this formula:—

$$\frac{\text{Solids not fat} \times 100}{9} = \text{percentage of pure milk present.}$$

For ordinary purposes the residue left from removal of the fat (by treating with 15 volumes of ether and filtering) is exhausted with weak boiling alcohol to extract the sugar. This is filtered and the filtrate evaporated to dryness and weighed. The second residue is ignited and the proteins determined by deducting the weight of the ash.

Farrington and Woll's Rule.—Divide densimeter reading by 4, add to this $\frac{1}{5}$ the percentage of fat; result is solids not fat.

Detection of Sterilized Milk (Storch).—First add a very dilute starch and KI solution, and then a drop or two of 1 : 10 H_2O_2. Milk heated above 175° F. remains unchanged; fresh milk or milk not heated to this temperature is colored blue.

Microscopically one finds many leucocytes in cases of mastitis with abscess-formation. The staphylococcus pyogenes albus is nearly always present in breast-milk. Streptococci are numerous in cases of infection. According to von Jaksch, the tubercle bacillus is occasionally present in the milk of phthisic women. Bacteria gaining access to pasteurized milk grow better than in fresh milk.

Finding Tubercle Bacilli in Milk (Brooks).—Shake well 50 c.c. of the milk with 10 c.c. of phenol; take centrifugalized sediment, dry in flame, wash for a few minutes in equal parts of alcohol and ether to remove fat, dry again and stain in usual way.

THE URINE.

In the practical examination of the urine for clinic purposes one should have a part or the whole of the mixed urine for twenty-four hours: say, from 7 A.M. to 7 A.M. The urine is kept in a cool place in a clean, well-corked, half-gallon bottle, into which has been dropped an ounce of a saturated aqueous solution of boric acid, or 5 grains of chloral hydrate or salicylic acid to the pint. Immediately after each micturition the urine passed should be added to the bottle and the cork replaced. Whenever possible, for microscopic examination, the urine, espe-

The intense yellow color after taking cascara, rhubarb, and senna is due to chrysophanic acid (brilliant red on treating with alkalies; soluble in ether). Powdered Zn removes the red color of chrysophanic acid, but not of santonin. $FeCl_3$ added to the urine turns it dark after taking tannin or arhovin. There may be a black deposit in the urine from large doses of Bi. Balsam copaiba in urine sometimes gives a red cloud on adding HCl, turning violet on heating. Naphtalin gives a blue fluorescence on adding a few drops of NH_4HO.

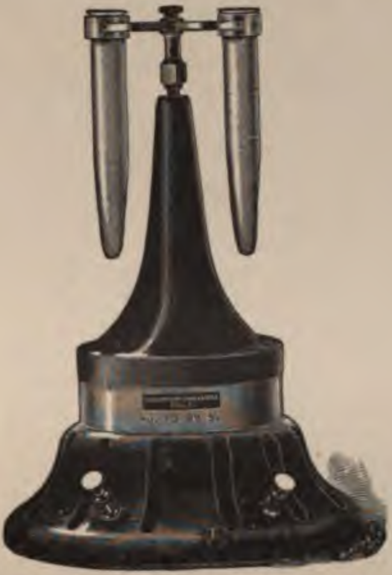


Fig. 72.—Purdy's Electric Centrifuge.

Pathologically the urine is very pale in hysteria, dread, and anxiety; after convulsions, and in diabetes insipidus. In diabetes mellitus it is pale and opalescent, often with a greenish tinge if there is much sugar. It is also pale in chronic interstitial nephritis, chronic diffuse nephritis, amyloid disease, hydronephrosis, anemia, chlorosis, and convalescence from acute affections. Milky urine is noted in pyuria (pyelitis, cystitis, gonorrhea), phosphaturia, and chyluria.

The urine is generally high-colored in renal congestions, acute nephritis, and acute febrile and inflammatory diseases. It is rendered darker by concentration from any cause (diarrhea, vomiting, sweating freely) and in melancholia. In hematuria (cancer, sarcoma, or trauma) the blood is red or smoky; in hematuria it is smoky-brown or even black; in hemoglobinuria (malaria, scarlet fever, $KClO_3$ poisoning) it is pink or even porter-colored. Carbolic acid poisoning renders the urine dark-brown to greenish-black, especially on standing (turns alkaline), from oxidation of pyrocatechin; the same color is noted in poisoning by creosote, cresol, guaiacol, cyanids, or trional or arsin. In sulphonal poisoning the urine is brown-red, or almost black, from hematoporphyrin.

Choluria, or the presence of bile, is marked by a bright-yellow to green-brown or porter color, with a yellow foam on shaking. It is dark-yellow, nearly black, in pathologic urobilinuria. The normal yellow hue gradually turns black after eating damson plums; the change takes place at once on adding oxidizing agents, such as HNO_3 or $FeCl_3$. A mixture of urates and phosphates or pus and phosphates exhibits a dark-gray appearance. In pernicious anemia the urine may be dark-brown (urobilin). Black urine (especially after standing) is noted in persistent jaundice, melanotic sarcoma, marked indicanuria (disappears on pptg. with milk of lime), some cases of phthisis (after urine has stood a long time), and alkaptonuria. Alkaptonuria is often observed in brothers and sisters. Alkapton is probably a derivative of tyrosin.

The urine is purple or pinkish in color, from excess of urates, in acute gout, rheumatism, pneumonia, and liver disorders (lithemia). It is rosy in chyluria with hematuria, due to filariasis. It rarely shows a dirty-blue or green scum in cholera, typhus, cystitis, or nephritis, from decomposition of excess of indican. In trional poisoning it shows a cherry tinge. In bacteriuria the urine is grayish and opalescent. The urine is sometimes phosphorescent in healthy persons during micturition. The normal fluorescence of urine is increased by the presence of albumin or by ammoniacal decomposition. Deep-blue urine when freshly voided, has been noted with non-pigmented carcinoma of stomach or liver. Normal urine is feebly levorotatory, from traces of phenol, indol, skatol, and glycuronates. Albumin and globulin increase this property.

ODOR.

The slightly aromatic odor of fresh urine is due to minute amounts of phenylic, taurylic, damolic, and damoluric acids and volatile ethers. The strong urinous odor of decomposed samples is due to ammonium carbonate and sulphid. Nearly every old urine emits an odor of H_2S when treated with mineral acids.

The more concentrated the urine, the stronger is its odor. On standing for some days (sooner in warm weather) it becomes ammoniacal and putrescent. Characteristic odors are imparted by the ingestion of asparagus (very offensive, methyl mercaptan), asafetida, cabbage, carbolic acid, cauliflower, copaiba, cubebs, garlic, parsnips, saffron, santal-oil, spices, Tolu, valerian, etc. Turpentine, eucalyptus, and terebene give a scent like violets.

Urine which is pungent and ammoniacal when first passed is characteristic of chronic cystitis or paralytic retention. It is peculiarly putrid in pyelitis and pyonephrosis. The aroma is sweet and fruity or hay-like in diabetes mellitus with acetonuria (like apples or chloroform). The smell is offensive, like stale fish, in bacteriuria. It is almost absent in obstructive retention, forming cysts. A fecal odor is a sign of rectovesic fistula or abscess. The urine is fragrant, like sweet-brier, in cystinuria; but when the cystin decomposes it smells like sewer-gas. H_2S may be formed in the bladder by bacterial infection, or may be resorbed from the intestines or from a depot of pus adjoining the bladder.

TRANSPARENCY.

Normal urine is quite clear when freshly passed. On standing a slight cloud of mucus and epithelia forms near the bottom in a few minutes; on cooling to near f. p. a "brick dust" sediment of acid urates is frequently seen, especially if the urine is scanty; it becomes dull and opaque from fission-fungi in twenty-four to forty-eight hours; alkaline fermentation is accompanied by cloudiness, due to earthy and triple phosphates, ammonium urate, and bacteria. Diminished pigmentation tends to ppt. uric acid crystals. A temporary cloudiness occurs from excess of vegetable food-salts or from mental strain (fixed alkaline reaction). Permanent cloudiness, or "phosphaturia," depends on low acidity, with consequent precipitation of earthy phosphates, and is due to nervous debility or indigestion with hyperchlorhydria. The urine is often turbid in fevers from precipitation of urates (white, yellow, brown, or pink). Crystalline sodium urate is occasionally observed in acute febrile diseases of children. A deposit of uric acid and urates within three or four hours takes place in disorders of the digestive apparatus; this precipitation takes place at once or nearly so in calculus. Early deposition of the acid also occurs in convalescence from febrile complaints, particularly articular rheumatism; the middle period of chronic interstitial nephritis; chorea, diabetes, and enlarged spleen. Infarcts of uric acid are common in infants, who strain and cry out when passing water; there is a pink or yellowish sandy deposit on the diapers. Cloudy urine (epithelia and urates) is the rule during the first days of life. Opalescence may be due to various substances (blood, for example) in suspension.

The presence of a sediment of a normal ingredient is no indication whatever of excess or of the amount in any way; but rather of some change in the reaction or concentration of the urine. The following short list will aid in differentiating the most common forms of sediment and cloudiness:—

1. Turbidity cleared by heat (below b.p.) or an alkaline hydrate = urates (acid varieties, pink, yellow, or fawn-colored; ammonium urate, white).

2. Not cleared by heat, but with acetic acid = phosphates (whitish).

3. Insoluble in acetic, but soluble in hydrochloric, acid = calcium oxalate (whitish, resembling cloud of mucus, and mixed with it; "envelope" microscopic crystals).

4. Cleared up by ammonium hydrate, but not by heat = cystin (greenish).

5. Intensified more or less by heat and acids:—

Blood: red, smoky, or chocolate brown; microscopic corpuscles.

Mucus: white and stringy; liquefied by liquor potassæ.

Pus: white and creamy; made gelatinous by liquor potassæ.

Semen or epithelia: both diagnosed only with the microscope.

6. Unaffected by heat, chemic agents, or filtration = bacteria (B. protei, bacterium, and micrococcus ureæ; mold or yeast-plants, and specific germs). Cleared by treating with animal charcoal and filtering.

7. Granular precipitate resembling Cayenne pepper (sometimes brown or yellow and rarely white) = uric acid.

8. Milky appearance, most marked near top of fluid = fat or chyle (both cleared more or less by shaking with ether). A milky appearance of the urine may also be due to the spontaneous separation out of albumose.

CONSISTENCE.

Normal urine is limpid and nearly aqueous. It is thick, viscid, and ammoniacal in chronic cystitis. In fibrinuria it gelatinizes on standing, forming a grayish coagulum insoluble in water, but dissolved by pepsin and 1 per cent. HCl. In chyluria with fibrinuria the pink urine may coagulate into jelly-like clots before voiding. Croupous coagula have been noted after too strong urethral injections. In the sediment of urogenital tuberculosis there are pinhead, crumb-like flocculi consisting of pus cells, fatty detritus, and colonies of bacilli. Shreds of mucous membrane are occasionally exfoliated in acute septic cystitis. The presence of albumin, sugar, or bile gives rise to a persistent foam on shaking. In distilling urine, add H_3PO_4 to prevent frothing.

CHEMIC REACTION.

The reaction of the urine is normally slightly acid (alkaline as it leaves the capsule) and due to NaH_2PO_4, which is derived from the Na_2HPO_4 of the blood by reaction with carbonic, uric, hippuric, and sulphuric acids.

Acid urine is secreted from an alkaline blood, because the PO_4 radical is not readily reabsorbed from the glomerules, whereas HO and CO_3 are easily absorbed. Normal urine is never alkaline to phenolphthalein or acid to methyl-orange, and corresponds to the interval in reaction between NaH_2PO_4 and Na_2HPO_4. An amphoteric urine results when the acid equivalents of Na_2HPO_4 equal the basic equivalents of NaH_2PO_4. The degree of acidity is estimated in the usual way with decinormal alkali, using litmus as an indicator. The mixture of acid and neutral phosphates interferes with the end-reaction, making the findings a trifle high. The total acidity corresponds to 2 to 4 gm. of oxalic acid; in hyperacidity it may reach 10.

Determination of Total Acidity of Urine.—Treat 25 c.c. of urine with 1 or 2 drops of 0.5 per cent. alcoholic solution phenolphthalein and 15 gm. powdered $K_2C_2O_4$, shaking the solution for a minute and titrating at once with $n/_{10}$ NaHO, shaking the flask during titration. The average total acidity for the 24-hour urine (about 600 c.c. $n/_{10}$ alkali) is nearly equally divided between mineral and organic acidity. One per cent. alizarin gives a pure yellow if free acids are present—deep violet with combined acid salts; absence of either color shows acid and alkaline salts (Na_2HPO_4). The amount of $n/_{10}$ HCl required to produce a pure yellow color = alkaline salts. The amount of $n/_{10}$ NaOH needed to give a deep violet color = acid salts.

The urine is sometimes alkaline after meals, especially if much vegetable food has been taken, said alkalinity being due to the carbonates and bicarbonates of the alkali metals. It is occasionally amphoteric, from the presence of both acid and alkaline phosphates, after decomposition of urea has begun. Meats and cereals yield an acid ash and render the urine more acid.

On standing acid urine often becomes more acid, from enzyme action of mucus on coloring matters, causing lactic and acetic acid fermentation. Usually, however, it becomes less acid, owing to decomposition of neutral urates by NaH_2PO_4, forming acid urates and uric acid, which are insoluble and hence do not influence the reaction.

In four or five days (sooner if warm weather, or if feebly acid and of low density) it always undergoes ammoniacal fermentation from the action of the fission-fungi on urea:—

$$N_2H_4CO + 2H_2O = 2(NH_4)_2CO_3$$

The surface of the urine becomes covered with a film of fungi and bacteria, entangling crystals of ammonium urate and ammonium magnesium phosphate. Organic acids formed by fermentation in the stomach, and oxidized to carbonates, may also render the urine alkaline.

Urinary acidity is increased by excess of meat, prolonged muscular exercise, and ingestion of chloral (forming urochloralic acid with glycuronic acid), saccharin, and mineral (slightly), or benzoic acids. Alkalinity (fixed) is favored by a vegetable diet, hot or cold baths, free perspiration, and alkaline hydrates or carbonates and salts of vegetable acids. The normal acidity is decreased after meals, often becoming neutral in three to five hours, rising again as the food passes into the intestines.

Pathologically the urine is sharply acid in lithemia, gout, bronchial asthma, acute rheumatism, diabetes, pleurisy, pneumonia, and other inflammations; also in starvation, scurvy, leukemia, and chronic interstitial nephritis. Its hyperacidity in gastric achlorhydria (intestinal putrefaction) is due to free fatty acids (lipaciduria).

Fixed alkalinity is distinguished by the fact that the red color of the litmus-paper is not restored by drying. It is noted, with deposit of earthy phosphates ("phosphaturia"), in chlorosis, anemia, general debility, nervous dyspepsia, organic nervous diseases, resorption of alkaline transudates, hyperchlorhydria, atrophic gastritis, and when there is loss of gastric juice by fistula or vomiting, or gastric lavage. Much blood or pus in the urine also causes fixed alkalinity.

The volatile alkalinity of ammoniacal urine is shown by the red color of litmus being restored on drying. It is observed in freshly passed urine, with deposit of earthy and triple phosphates, in chronic cystitis and in retention of urine due to paraplegia, myelitis, enlarged prostate, or urethral stricture. In pyelitis the urine is always acid unless there are complications; in cystitis due to gonorrhea, tuberculosis or uric acid stone it is usually acid. The urine segregated from a surgical kidney may be ammoniacal.

The normal digestive curve is always increased in gastrosuccorrhea; it is absent in atrophic gastritis, severe chronic gastritis, and cancer of the stomach.

DAILY QUANTITY.

This ordinarily ranges from 1000 to 1200 c.c. for men; 900 to 1000 c.c. for women, and for children relatively more than for adults in proportion to body-weight. There is about 1 c.c. secreted per hour for each kg. of body-weight. More is passed in the afternoon, less in the forenoon, and least at night; the maximum is a few hours after meals. High altitudes and the summer season decrease the quantity of urine.

The quantity of urine is increased by cold and a moist atmosphere, nervous excitement, moderate exercise, liberal potations, and the use of diuretics, including alcohol and sugar. The quantity is decreased by vicarious action of the skin, bowels, or lungs; by rest; by nursing, and by fluid or dietary abstinence.

Permanent polyuria is observed in both forms of diabetes (up to 10 liters daily), and in chronic interstitial nephritis (more night than day); also in amyloid kidney, cystic renal degeneration, renal tuberculosis, pyelitis, constipation, cardiac hypertrophy, formation of exudations, and in organic nervous lesions, especially of medulla (sugar also present in about half the cases of hemorrhage). Diabetes insipidus is usually due either to cerebral syphilis or injury to the nervous system.

Temporary or paroxysmal polyuria is noted in hydronephrosis, alternating with periods of diminution; in convalescence from acute affections, particularly with resorption of serous effusions; also in hysteria (hydruria), excitement, and some cases of nervous debility, convulsions, chorea, and migraine.

Oliguria is seen especially in acute and chronic diffuse nephritis and in renal congestion (increased quantity in first stage of active variety) from cantharides, turpentine, etc. Other causes of diminished urine are the fastigium and defervescence of acute fevers, diarrhea, dysentery, cholera, persistent vomiting, gastric dilation, pyloric stenosis, cardiac dilation and insufficiency, chronic lead poisoning, hepatic cirrhosis with dropsy, melancholia, emphysema, and chronic bronchitis. In renal calculus the amount of urine is temporarily diminished, with pain and frequent micturition, becoming copious when the obstruction is removed.

The amount of urine (Croftan) is an index of blood-pressure, since it depends on the state of the renal epithelia and the rapidity of blood-flow through the kidneys. Under normal circumstances the hourly daily excretion is double the nocturnal hourly secretion. The opposite condition (nycturia) obtains in many prostatic, vesical, and renal affections, and in extra-urinary diseases accompanied by myocardial weakness.

Partial or complete suppression (anuria) is sometimes noted in acute and chronic nephritis, and following ether anesthesia, reflex shock from operation (particularly genito-urinary), catheterization (urinary fever), internal injuries, severe hemorrhages, or strangulated bowel. Obstructive suppression is encountered when the ureter is plugged by a calculus and the other kidney is absent or non-functionating; obstruction of ureters, by valves or twists, by a colon growth or by a tumor at the vesic orifices, and by irritation reflected to the kidneys from a diseased bladder, enlarged prostate, or old stricture (this form is transient and may follow a debauch). Suppression is also noted in some cases of hysteria, puerperal eclampsia, the algid stage of cholera, grave fevers and inflammations, and toward the fatal end of renal and other diseases. In thrombosis of the renal vein anuria is preceded by the passage of blood and blood-casts. In obstructive suppression the urine is pale and watery, with no albumin or casts, as a rule. In non-obstructive suppression the urine is concentrated and is likely to contain albumin, blood, and casts. Retention of urine in the bladder may be due to urethral obstruction (calculus, abscess, stricture, spasm), or a paralyzed bladder, and is readily diagnosed by percussion and catheterization. Saline diuretics act by increasing osmotic pressure of plasma, causing hydremic plethora and consequent rise of blood-pressure.

SPECIFIC GRAVITY.

This is determined by means of a urinometer and jar, or more exactly by the Westphal balance. The best urinometer is that of Squibb, with a spindle-shaped bulb and a fluted cylinder. When the temperature of the urine is not the same as the standard of the instrument, about 6° F. may be allowed for each degree above or below this standard (⅓ urinometer degree for each C. degree of temperature above or below standard). The sp. gr. beads are convenient for very small amounts of urine.

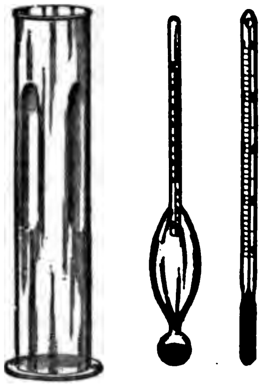


Fig. 73.—Squibb's Urinometer.

The normal sp. gr. of urine ranges from 1.015 to 1.025. In young infants it is often below 1.005. The sp. gr. varies inversely with the quantity, as a rule; hence, is higher in summer than in winter. It is raised by excess of proteid foods or salts (medicinal or alimental), active muscular exercise, and copious diaphoresis. It is lowered by fasting, chilling, nervous excitement, milk and vegetable diet, and the imbibition of much fluid.

Pathologically the urine is of high sp. gr. in acute fevers and inflammations, goutiness, dyspepsia, melancholia, most cases of functional albuminuria, acute diffuse nephritis, cyanotic renal induration, and markedly with polyuria in diabetes mellitus.

A low sp. gr. is the rule in all forms of Bright's disease (with oliguria or polyuria) and renal insufficiency except the two above mentioned. A fall of density may precede uremic convulsions for several days. The density is also reduced in pyelitis, chronic cystitis (urea broken up and volatilized), diabetes insipidus (may be 1.000 to 1.005), hysteria, anemia, chlorosis, senility, cachexias, organic liver disease, and most chronic diseases attended with inanition; serous exudations (dropsy or edema); after copious sweating, vomiting, or diarrhea; in convalescence from acute diseases, and toward the fatal end of acute maladies. A low sp. gr. with a high color is specially significant of the approach of death in chronic diseases. Generally speaking, decrease of sp. gr. without a corresponding increase of water is a bad sign.

TOTAL SOLIDS.

The average daily quantity of total solids in the male adult is about 70 gm., of which nearly 1/2 is urea, 1/5 NaCl, and 1/25 phosphates. In each 1000 c.c. of urine there are about 967 parts of water and 33 parts of solids, 2/3 being organic and 1/3 inorganic.

The total solids in gm. per 1000 c.c. can be calculated approximately by multiplying the last two figures of the sp. gr. by 2 1/3; this is called Haeser's coefficient. Another method to find the amount of solids in grains is to multiply the last two figures of the sp. gr. by the number of ounces of urine daily, then add to the product 1/10 of itself. Ten per cent. should be deducted from the total solids for persons between 40 and 50; 20 per cent. between 50 and 60; 30 per cent. between 60 and 70; and 50 per cent. above 70. Deduct 1/3 from total average of solids in persons who have fasted for two or more days; for total rest deduct 1/10. An exact determination is made by evaporating the urine of twenty-four hours to dryness, finishing on the water-bath and in the water-oven.

Renal permeability is greatly diminished in chronic interstitial nephritis. Iodin is normally eliminated in the urine within a half-hour after the administration of a gelatin capsule of KI. In cases of interstitial nephritis it cannot be detected for from five to twenty hours. The intramuscular injection of 1 c.c. of a 0.5-per-cent. solution of phloridzin causes the appearance of sugar in the urine of healthy subjects in from fifteen to thirty minutes, and amounting from 1/2 to 2 gm., mostly in the first hour. A decrease in the sugar to below 1/2 gm., or a delay beyond the hour, indicates renal insufficiency.

In some fevers and severe cachectic conditions the ratio of daily excretion of Na salts (normally 7.5 gm. Na_2O) to K salts (normally 3 gm. K_2O) is nearly reversed. Ca and Mg occur almost exclusively as phosphates. A predominance of Ca (oxaluria, phosphaturia) over Mg may depend upon a catarrhal condition of the colon, interfering with the normal elimination of Ca by this route.

CRYOSCOPY.

The f. p. of normal urine is — 1° to — 2° C. A lessening of the urinary solids, as in renal inadequacy from any cause, raises the f. p. above — 1° C. For clinical purposes a Beckmann thermometer is suspended in a large test-tube containing 15 to 20 c.c. of the urine (or blood-serum), and this tube is then placed in a larger tube, in order to have an air-space between the smaller tube and the beaker holding the freezing mixture of salt and ice. The tube of urine should be agitated as freezing takes place, the mercury sinking, then rising to the freezing point. This method is of some value in surgical renal diseases to show the relative functional power of each kidney, using the urines obtained by ureteral catheterization. The f. p. of blood-serum (normally — 0.55° to 0.579° C.) falls *pari passu* with the rise in the urinary f. p. Casper and Kuemmell state that nephrectomy is contraindicated when the f. p. of the blood-serum is below — 0.58° C., or the f. p. of the urine (from the opposite kidney), above — 0.8° C. On the whole, since cryoscopy does not distinguish between variable preformed food salts (NaCl) and the excretory products of metabolism (urea), it is not to be compared in clinic value with the readily performed separate estimations of urea, phosphates, etc.

Anemias tend to raise the f. p. of blood (to — 0.52°) and urine; malaria, diabetes, and blood and heart diseases have the opposite effect (blood down to — 0.60°). For standard values the product of △ (f. p. of urine) times the amount of urine (√ or valence number) in c.c. is found to vary between 776 and 3770. The electric conductivity of urine depends on the total mineral content, and is, for practical purposes, no more available than cryoscopic methods. NaCl is the chief electrolyte; urea, the leading non-electrolyte.

NORMAL CONSTITUENTS.

CHLORIDS.

These are derived entirely from the chlorids of the food, chiefly NaCl, and amount to 10 to 16 gm. daily. The amount excreted also varies directly with the volume of urine. It is decreased by rest and fasting, increased by exercise. The digestive curve of chlorids corresponds closely with the curve of acidity.

Pathologically an absolute increase (chloruria with hydruria) is noted in diabetes insipidus (up to 30 gm.), Bright's disease, after epileptic attacks, in the declining stage of dropsy (resorption), and after the crisis of acute fevers and inflammations (resorption); also in prurigo and intermittent fevers, and after chloroform or thyroid administration.

An absolute decrease is observed during fasting and in most fevers before and up to the febrile crisis, particularly in pneumonia, in which chlorids may be even temporarily absent. A decrease is also found in pleurisy, acute meningitis, the nephritides, anemia, cachectic conditions, and chronic dropsic complaints; chronic lead poisoning; chronic mental diseases;

cholera, diarrhea, and vomiting; acute articular rheumatism; gastrectasis with pyloric stenosis; hyperchlorhydria, or gastric carcinoma. In benign pyloric stenosis there is a small amount of chlorids and also of N; little chlorids with relatively large amount of N in malignant stenosis. Retention of chlorids often precedes retention of water in edema.

Estimation of Chlorids. Mohr's Volumetric Method.—Take 10 c.c. of urine, dilute with 50 c.c. or more of H_2O, add ½ c.c. of 20 per cent. K_2CrO_4 (indicator), then titrate with standard $AgNO_3$ solution (same as for sanitary analysis of water) until a permanent pink or orange color appears. Each c.c. of the standard solution used is equivalent to 0.01 gm. NaCl or 0.006065 gm. Cl. One c.c. of the standard solution should be subtracted, so as to allow for small quantities of organic substances that react with the silver salt.

Purdy's Centrifugal Method.—To 10 c.c. of urine add 1 c.c. of strong HNO_3 and 4 c.c. of $AgNO_3$ (dram to ounce). Invert 3 times, let stand for 3 minutes, then revolve for 3 minutes at 1200 revolutions. The percentage by weight of Cl equals 1/12 of the bulk percentage (usually 6 to 8 per cent.).

PHOSPHATES.

The earthy phosphates (Ca and Mg) amount to 1 to 1.5 gm. daily and are derived chiefly from the food, and partly from the breaking down of nuclein and lecithin. The alkaline phosphates, from similar sources, amount to 2 to 4 gm. in twenty-four hours. The phosphates of sodium in the urine include NaH_2PO_4, Na_2HPO_4, Na_3PO_4, and $Na_3PO_4.NaHO$ (superbasic). The monophosphate is converted into di- and tri- phosphates by addition of alkaline hydrates or carbonates. NaH_2PO_4 liberates CO_2 from alkaline carbonates. The total phosphoric acid (2.5 to 3.5 gm. P_2O_5; 60 per cent. acid phosphate, 40 per cent. neutral phosphate) is increased by a meat diet, fasting, and cerebral excitants. It is decreased on a vegetable diet (acid combines with earthy salts and is not absorbed), by pregnancy, and by cerebral depressants.

The earthy phosphates are increased in rickets (children) or osteomalacia (adults), chronic rheumatoid arthritis (vary little from the normal; twice as much Ca excreted as ingested), diffuse periostitis, neurasthenia, melancholia, general debility, mental overwork, chronic alcoholism, and central nervous diseases (epilepsy, meningitis); tuberculosis, carcinoma, leukemia, and acute yellow atrophy.

The alkaline phosphates are greatly augmented in "phosphatic diabetes": an affection characterized by acid polyuria, thirst, rapid emaciation, great nervous irritability, dyspepsia, and distressing lumbar pains. This condition may alternate with diabetes mellitus.

Both kinds of phosphates are diminished in all forms of Bright's disease and renal insufficiency and in chronic lead poisoning. Less important is the decrease noticed in gout, rheumatism, intestinal indigestion, anemia, chlorosis, empyema, hepatic cirrhosis, acute yellow atrophy, and intermittent and most acute fevers except meningitis.

Earthy phosphates are held in solution in the urine as acid phosphates by the acid reaction and CO_2. Heat drives off this gas and so ppts. the earthy phosphates as normal salts. Alkaline phosphates are never spontaneously pptd. The phosphates aid in keeping uric acid and oxalates in solution. Phosphates are excreted in the urine most freely when chlorids are retained, and *vice versâ.*

The ratio of N to P_2O_5 in the urine (normally 100 to 17) is greatly increased, and may be doubled in malignant diseases generally. P (from bones) increases much more than N in hunger and inanition.

Volumetric Determination of Total Phosphoric Acid (Ogden).—Three reagents are used: 1. A standard solution of pure uranium nitrate, containing 35.5 gm. per liter of distilled water; each c.c. corresponds to 0.005 gm. P_2O_5. 2. A solution of 100 gm. of sodium acetate and 100 c.c. of 30 per cent. acetic acid in sufficient distilled water to make a liter. 3. A cochineal tincture prepared by digesting a few gm. of cochineal with 250 c.c. of diluted alcohol (1 part to 3 of water) and filtering after several hours. Take 50 c.c. of the urine, add 5 c.c. of No. 2 and a few drops of No. 3, and warm mixture to 80° C. over the water-bath. Then titrate the hot mixture with solution No. 1 until a faint, but distinct, permanent green color appears to mark the reaction with U as soon as the phosphoric acid is entirely pptd.

Purdy's Centrifugal Method.—To 10 c.c. of the urine add 2 c.c. of 50 per cent. acetic acid and 3 c.c. of 5 per cent. solution of uranium nitrate. Invert 3 times, let stand 3 minutes, and revolve for 3 minutes at 1200 revolutions per minute. The percentage, by weight, of P_2O_5 equals $1/85$ of the bulk percentage of uranyl phosphate ($H[UO_2]PO_4$), usually from 8 to 10 per cent. Albumin must first be removed by heat and acetic acid.

To separate the earthy from the alkaline phosphates, the first step in Cook's centrifugal test for uric acid may be followed (or the urine may be alkalinized with NaHO, heated and filtered), and then the above reagents added. It should not be forgotten that "phosphaturia" depends not on the amount of earthy phosphates, but on the neutral or alkaline reaction of the urine. In comparing the amounts of earthy phosphates and alkaline phosphates, it is best to use gravimetric methods, throwing down first the earthy phosphates, then treating the filtrate with acetic acid and uranium nitrate, calculating this second ppt. as NaH_2PO_4 by multiplying by $120/367$.

CARBONATES.

A liter of normal human urine contains 40 to 50 c.c. of CO_2; if neutral or alkaline, over 100 c.c. This forms both normal and acid salts with the alkalies and alkaline earths. The amount of carbonates in normal urine is generally minute, except after the administration of the salts of the vegetable acids or the ingestion of these acids as foods or medicine, giving rise to fixed alkalinity. Ammonium carbonate in appreciable quantity in freshly passed urine indicates decomposition of the fluid within the bladder, nearly always from chronic cystitis.

The amount of iron (combined with uric acid, etc.) present in the residue from a liter of urine varies from 3 to 11 mg. Traces of nitrates, fluorids, and silicates are found in every urine. H_2O_2 has been detected in fresh urine by its bleaching effect on indigo.

SULPHATES.

The mineral sulphates (mostly K and Na) amount from 1.5 to 3 gm. daily, and are derived chiefly from meat and muscle, the contained S being oxidized to H_2SO_4, and this uniting with the metals.

The proportion of mineral sulphates is increased by meat diet, active exercise, inhalations of pure O, and ingestion of S compounds. It is decreased by a vegetable diet or salicylates.

Pathologically the mineral sulphates show an absolute increase in acute fevers and inflammations, especially rheumatism, pneumonia, cerebritis, meningitis, and myelitis; also in obstructive jaundice and both kinds of diabetes. A subnormal quantity is noted in acute and chronic renal diseases, eczema, chlorosis, leukemia, and carbolic acid poisoning (combines with H_2SO_4 to form phenol-potassium sulphate). Generally an increase or decrease of mineral sulphates runs parallel with that of urea.

Centrifugal Estimation (Purdy).—To 10 c.c. of urine add 5 c.c. standard $BaCl_2$ solution (4 parts of $BaCl_2$, 1 part of strong HCl, and 16 parts of distilled water). Let stand 3 minutes after shaking, and revolve 3 minutes. The percentage by weight of SO_3 equals ¼ bulk percentage (usually about 0.8) of $BaSO_4$.

The conjugate or ethereal (aromatic, combined) sulphates originate chiefly from putrefaction in the small intestines, being formed in the liver from cystein (by enzymic action), phenol, skatol, paracresol, and indol. Creosote and other aromatic intestinal antiseptics produce ethereal sulphates not distinguishable from those due to putrefaction.

The principal members of the group are indoxyl-potassium sulphate, or "indican" ($C_8H_6NO.SO_2.OK$), phenol-potassium sulphate ($C_6H_5OSO_3K$), and skatoxyl-potassium sulphate ($C_9H_8NO.SO_2K$). The ratio of ethereal to mineral sulphates is normally about 1 to 10. The daily excretion of indican is normally about 6.6 mg. The mineral and conjugate sulphates together are termed the "acid" sulphates. The neutral, organic, or suboxidized S of the urine constitutes from 12 to 15 per cent. of the whole, and comprises H_2S, $(C_2H_5)_2S$, thiosulphates, sulphocyanates, and derivatives of cystin and taurin. It yields a black ppt. on boiling with an alkaline Pb solution.

Indican is in excess on a meat diet (putrefaction of proteins in *primæ viæ*—least with milk diet, casein, and gelatin); also in hypo- and achlor- hydria, and sometimes in diarrhea, peritonitis, perityphlitis, appendicitis, hepatic or gastric carcinoma, diphtheria, scarlet fever, and erysipelas. An enormous excess is often noted in cholera and intestinal obstruction or tuberculosis. The same conditions (except simple obstruction) give rise to excess (above 0.03 gm.) of phenol and paracresol. Indican is not formed from the albumins of the organism itself. It is markedly diminished by calomel and lactic acid; castor-oil and salines increase it. Paracresol is more abundant on a vegetable than on a mineral diet.

Clinic Test for Indican.—To ⅛ test-tube of urine add ¼ as much HCl and a few crystals of KNO_3. Boil the mixture, let cool, and shake with 2 c.c. of chloroform. If indican is normal in amount, the layer of $CHCl_3$ will be colorless. If indican is in excess, the chloroform on settling will be colored light blue to a deep purple, depending on the amount. Iodids taken internally color the chloroform blue (decolorized by $Na_2S_2O_3$).

By further oxidation indigo-blue is changed to colorless isatin. Jaffe's test for indican is made more certain and delicate by first adding ¼ the volume of 10 per cent. lead acetate solution, and testing filtrate. Skatoxyl (so-called urorosein) imparts a red color to the supernatant liquid. On shaking with amyl alcohol, this takes up the red pigment, which disappears on adding NaHO, and reappears on the subsequent addition of HCl. A well-marked reaction shows greatly increased intestinal putrefaction.

Indigo-red in the urine has the same significance as indican. It is recognized (Rosenbach) by adding HNO_3 drop by drop to the boiling urine, getting a deep red color with a violet foam on shaking. Skatoxyl-sulphuric acid and skatoxyl-carbonic acids also give a red or a violet color on treating the urine with HCl containing a little $FeCl_3$, after filtering off the sediment produced by lead acetate.

Robin's Quantitative Test for Indican.—Three reagents are required: (1) HCl containing 2 p.m. $FeCl_3$; (2) a 25 per cent. solution of $Pb(C_2H_3O_2)_2$; (3) $KClO_3$, 34.6 gm. per liter of water—contains 1 per cent. available Cl. To 10 c.c. of urine add 1 c.c. of lead acetate solution, and filter through a double filter. Put 5 c.c. of filtrate in test-tube, add 5 c.c. of reagent (1) and 2 c.c. of chloroform, and invert tube ten times. Now add from a dropper the $KClO_3$ solution until the blue color in the chloroform disappears; one to two drops normally cause decoloration.

Clinic Test for Phenol-potassium Sulphate.—Distill 25 c.c. of the urine with 5 per cent. of H_2SO_4 and add Br water to the distillate, getting a yellowish ppt. of tribromphenol. Millon's reagent gives a beautiful red color with distillate. An intense phenol reaction is noted in infectious fevers, chronic alcoholism and liver disease.

Salkowski's Method for Total Sulphuric Acid (Preformed and Conjugate SO_3).—Take 100 c.c. of urine in a beaker, acidulate with 5 c.c. HCl, boil, and add $BaCl_2$ until no more ppt. ensues. Collect ppt. on a small filter of known ash, and wash with hot distilled water till $BaCl_2$ disappears from filtrate. Then wash with hot alcohol and again with ether. Incinerate filter-paper and contents in a Pt crucible, cool, add a few drops of H_2SO_4 (to change any BaS to $BaSO_4$), heat again to redness, cool in a desiccator, weigh, and deduct weight of crucible and ash. 100 parts of $BaSO_4 = 34.33$ parts SO_3.

Salkowski's Method for Ethereal Sulphates.—Take 100 c.c. of clear, filtered urine; mix with an equal volume of alkaline $BaCl_2$ solution (1 part cold, saturated $BaCl_2$; 2 parts cold, saturated $Ba[HO]_2$); and stir thoroughly. After a few minutes filter into a dry graduate up to the 100 c.c. mark (half the urine), acidulate this portion with 10 c.c. HCl, boil, keep at 100° C. for an hour on the water-bath, and allow to stand for twenty-four hours or until completely settled. Then wash, dry, and weigh as for total sulphates. The difference between the total and the combined or ethereal sulphates represents the preformed or mineral sulphates.

UREA.

This compound is formed principally in the liver from the synthesis of CO_2 and NH_3, with elimination of water. It is in part the product of retrograde metamorphosis of the tissues, blood, and secretions, and to a minor extent it results from the splitting up of unassimilated nitrogenous food, its antecedent, in this event, being leucin principally. About 85 per cent. of the N taken into the body by way of nourishment is excreted as urea, and approximately $\frac{1}{7}$ of the total potential energy of foods consumed escapes unutilized in the form of this compound. A larger N-intake than is needed for endogenous metabolism leads only to an increased elimination of urea.

Urea is a neutral, crystalline substance with a bitter, cooling taste like that of saltpeter. It is highly soluble in water, and is used as a diuretic in cardiac cases of dropsy. On heating to 150° it melts and gives off NH_3, leaving biuret. Formalin added to the urine gives a white ppt. (methylene urea), which reduces Cu salts and may be mistaken for leucin.

Urea is lethal in the proportion of $\frac{1}{200}$ of the body-weight. According to Bouchard, the symptoms of so-called uremia may be ascribed to six other toxic substances in addition to urea. One of these is a myotic; another, a sialagogue; a third, narcotic; a fourth depresses temperature, and K salts (most important) and another substance are convulsants. Some of these poisons are probably pigments, as passing through charcoal lessens the noxious power of the urine by $\frac{1}{3}$.

The microbic poisons in the urine are alkaloidal in nature, in the blood, albuminoid; hence the kidneys probably exert an analytic action on toxalbumins. The toxicity of urine is due in part to absorbed toxins of the colon bacilli (Gilbert). Griffiths and Albu have isolated special toxins from the urine in a considerable variety of diseases. In gastrointestinal autotoxemia Bouchard found the urinary ptomains increased fiftyfold. According to Griffiths, a toxic base, propylglycocyamin (creatin, with propyl substituted for one H), is found in the urine of patients suffering from various affections.

Common symptoms of uremia are contracted pupils, headache, pruritus, amaurosis, shallow dyspnea (Cheyne-Stokes), vomiting, diarrhea, convulsions, coma, and hypothermia or hyperthermia. The type of uremia, whether comatose or convulsive, varies with the relative proportion in the blood of the corresponding toxins. The toxicity of urine is almost nil in uremic attacks, the urea in the blood being increased at times to thirty-fold the normal. The freezing point of the blood-serum is lowered to — 0.61° to — 0.67° C. in nephritis with uremia, owing to this molecular concentration. The diminished electric conductivity of blood-serum (due to excess of proteins from retained nitrogen) may be the direct cause of uremic cortic symptoms (Stern). Deficient urea excretion is a more reliable danger signal than the presence or amount of albumin. Uremia is infrequent in patients with marked edema, since the cells, already saturated with chlorids that cause the edema, do not so readily fix the urinary poisons. Two c.c. of normal urine is sufficient (one urotoxy) to kill a kg. of living matter. The urotoxic coefficient in health is 0.464 urotoxy per kg. of weight. The urine of sleep, though more dense, is nearly always less toxic than the day urine. Muscular exercise in the open air makes urine less toxic, probably by enhanced oxidation. Urine is generally more toxic in disease, the convulsive elements (potassium and coloring matter) predominating in fevers, because of increased breaking down of the tissues. It is less toxic in mania, more so in melancholia.

The normal daily quantity of urea excreted by way of the urine is from 17 to 40 gm. (usually 20 to 25 gm.), or, hourly, 15 to 32 mg. per kg. of body-weight. One-tenth less is excreted by women than by men of the same weight. Children, after the first month, have an output relatively double. In old age the proportion is reduced by half. Large persons obviously pass out more urea than small ones. The average percentage of urea for adult males is about 2 per cent. The maximum ratio is six hours after meals; the minimum in the early morning. One gm. urea (Simon) is equivalent to 13.72 gm. lean muscular tissue.

The urea of the urine is increased by proteid diet especially, and to a less extent by muscular exertion, caffein, opiates, electricity, the copious ingestion of liquids (increased disintegration of proteids), hot baths, alkaline chlorids, mineral acids, and a close atmosphere. It is decreased by a milk and vegetable diet, and to a less degree by fasting, loose bowels, free sweating, menstruation, alcohol, iron, lead, mercury, or digitalis; also often in normal pregnancy.

Pathologically an excess of urea is noted in acute febrile (before acme) and inflammatory diseases, diabetes mellitus and insipidus, dyspneic conditions, malaria and severe blood diseases, minor chorea, epilepsy, paralysis agitans, hepatic congestion, some gastrointestinal disorders, and in belladonna or early phosphorus poisoning.

A deficient quantity of urea is a most important feature of all forms of Bright's disease, and is due chiefly here to impaired nutrition of the renal cells. The total urea output is less ($\frac{3}{5}$ normal) in chronic gouty conditions than in chronic Bright's disease—distinction from chronic rheumatic and certain nervous conditions. A decrease is also observed in circulatory weakness, cachexia, and malnutrition (more in gastric cancer than in simple inanition); convalescence from acute febrile diseases; hepatic carcinoma, cirrhosis, and acute yellow atrophy (may be increased at first); acute gout and chronic rheumatism; osteomalacia; chronic lead poisoning; diarrhea, cholera, and excessive sudation; simple anemia and leukemia; melancholia, imbecility, catalepsy, hysteria; Addison's and Weil's disease; leprosy, pemphigus, impetigo, and shortly before death from any cause.

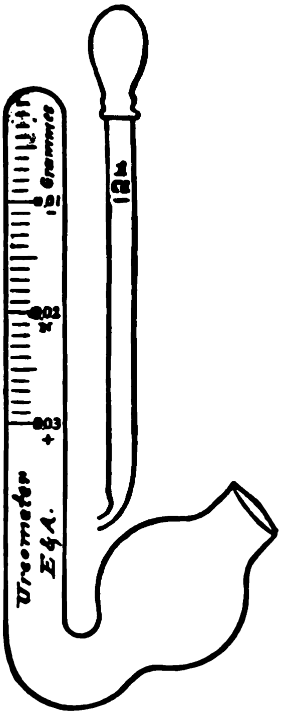


Fig. 74.—Doremus Ureometer.

Detection of Urea.—Evaporate a few drops of urine nearly to dryness with a drop of HNO_3. Large, colorless, rhombic or hexagonal plates of urea nitrate may be seen with the microscope.

Estimation of Urea.—The most practical methods for clinic purposes depend on decomposition of urea by freshly made sodium hypobromite in a strongly alkaline solution.

$$N_2H_4CO + 3NaBrO = 3NaBr + CO_2 + 2H_2O + 2N$$

The CO_2 is absorbed by the alkali, and the N collects at the closed top of the instrument.

The ureometer of Doremus is very simple and convenient. It is half-filled with 40 per cent. NaHO solution, 1 c.c. of Br introduced, and after this the instrument is filled by adding more water. One c.c. of the urine is now carefully introduced under the long arm by means of the pipet. The bubbles of N collect at the top, and when effervescence ceases the percentage of urea can be read off directly from the graduations on the cylinder (best immersed in water to the level of the column of fluid). One c.c. of N represents 0.0027 gm. urea. Due allowance should be made for altitude.

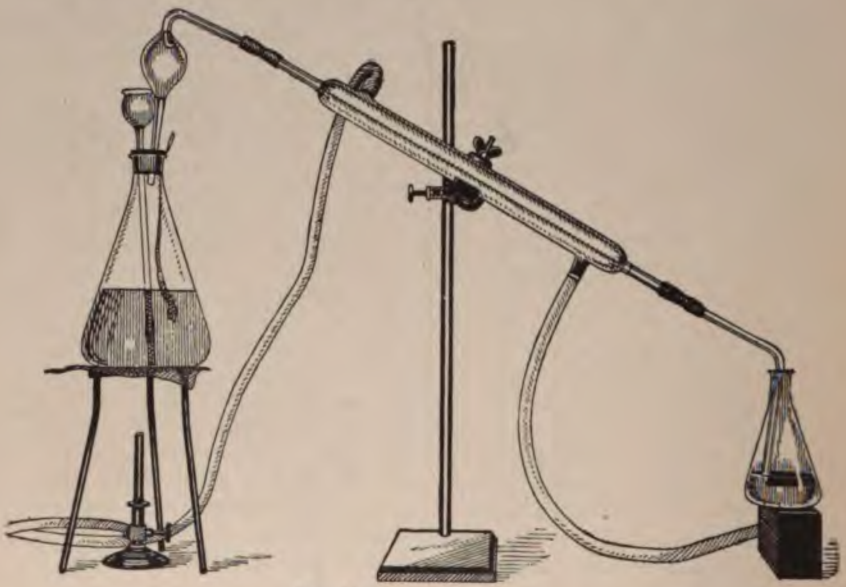


Fig. 75.—Kjeldahl Method.

The hypobromite method liberates only 93 per cent. of urea N, part of the deficiency being made up from creatinin, hippuric acid and purin bodies.

Fowler's Method.—Find sp. gr. of urine and of some liquor sodæ chlorinatæ, and mix 7 volumes of latter with 1 volume former. Let effervesce, with occasional shaking, for an hour, and determine sp. gr. of liquid at same temperature as before. The loss in units of sp. gr. from the original average of the mixed liquids, multiplied by 0.7791, gives the amount of urea in grams per 100 c.c.

Kjeldahl's Method to Determine Total Nitrogen.—The rationale of this method is as follows: On prolonged heating of any nitrogenous substance with H_2SO_4 all the N is converted into $(NH_4)_2SO_4$, which is decomposed on distilling with an alkali, and the liberated NH_3 collected in a known quantity of an $n/_{10}$ acid. The amount of the acid neutralized by the NH_3 is estimated by titrating with $n/_{10}$ alkali, and from this result the amount of N calculated.

Place 5 c.c. of urine in a 250 c.c. Kjeldahl flask; add 15 c.c. H_2SO_4 and ¼ gm. powdered $CuSO_4$; heat on a wire gauze under the hood till foaming ceases; then add 10 gm. powdered K_2SO_4 and continue boiling gently till the liquid is a light green. Then add a few grains of powdered $KMnO_4$ and heat again till fluid is light green. Allow to cool; transfer to a liter Erlenmeyer flask, adding the washings from the digestion flask; dilute to about 500 c.c., and add a few grains of powdered talc.

Insert a doubly-perforated rubber stopper with a Reitmaier bulb and a thistle-tube reaching nearly to the bottom of the flask. A long strip of red litmus-paper should be hung from the neck of the flask down into the liquid. Connect the upper end of the bulb with a condenser and a 500 c.c. receiving flask containing 50 c.c. of $n/_{10}$ oxalic acid.

Pour 50 to 60 c.c. of 50 per cent. NaHO into the large flask and distill over about 200 c.c. Then replace the receiving flask by another containing 10 c.c. of $n/_{10}$ oxalic acid and some water, and distill over 100 c.c. Now add a few drops of alcoholic rosolic-acid solution and titrate with $n/_{10}$ NaHO to a deep-pink color; the second, or check, flask should be free or nearly free from NH_3. A blank experiment with the reagents, but without the urine, should be done to ascertain the amount of N, if any, present in the reagents, and the result subtracted from the total. The difference between the number of c.c. of decinormal alkali taken and that left after neutralization gives, when multiplied by 0.0014 (N equivalent factor), the amount of N in 5 c.c. of urine.

According to Strauss, the retention N in 100 c.c. of normal blood-serum averages 25 to 30 mg.; in chronic parenchymatous nephritis without uremia, 40 mg.—with uremia, 62 mg.; chronic interstitial nephritis without uremia, 82 mg.—with uremia, 130 mg.; mixed type, 51 and 120 mg.

URIC ACID.

The alloxuric bodies are derived chiefly from the cleavage of nucleins of the body-cells and of ingested nucleoproteids; exogenic uric acid from oxypurins (nucleins) and aminopurins (purin bases) in food. All these nucleins or purin bodies are precipitated by ammoniacal silver-nitrate solution. The nuclein bases predominate in simple decomposition, while oxidation processes lead to the formation of uric acid, which normally exceeds the bases ten times in the output of alloxuric N, and may generally be taken as the criterion of nuclein metabolism. In gout, however, the lower oxidation products, such as xanthin, may exceed uric acid. Although urea may be formed artificially by oxidation of uric acid and many other organic compounds, there is no proof that the quantity of these two substances bears any necessary relation to each other. The normal daily output of uric acid is 0.4 to 0.8 gm.; of xanthin, 0.03 to 0.05 gm.

The pure uric acid is crystalline, and requires 16,000 parts of cold or 1600 parts of boiling water to dissolve it. It is ten to forty times as soluble in urine as in pure water. It is also soluble in glycerin, alkaline hydrates, carbonates, and phosphates. Na_2HPO_4 is the normal solvent for uric acid, forming acid urate and NaH_2PO_4.

Uric acid appears to be formed chiefly in the liver and spleen by the oxidation of purin bases. It exists in the urine normally as urates of Na and K, which are either neutral or acid, the latter class being subdivided into monacid or biurates, and triacid or quadriurates or tetraurates. The normal salts are readily soluble; acid urates much less so, especially in cold water. A brick-dust (lateritious) deposit of acid urates is commonly observed in acid concentrated urine, especially when chilled.

The daily excretion of uric acid and its congeners is increased by excess of proteid foods, especially meat-broths (hypoxanthin), glands, fish, asparagus, and young flesh; also by tea, coffee, cocoa (xanthin and hypoxanthin); fats, alcoholics (especially heavy wine), and the administration of liver, thymus glands, or nucleins. Its elimination is aided by the administration of sodium salicylate, disodic phosphate, colchicum, corrosive sublimate, or euonymin.

There is less increase of excretion after taking nucleins and purin bodies in gouty than in healthy subjects. About half of the purin bodies taken in food is excreted in the urine during the following twenty-four hours. When urine is allowed to stand in a warm place, its uric acid diminishes while oxalic acid increases.

The uric acid of the urine is decreased by a milk and vegetable diet (bread, butter, milk, sugar, eggs, potatoes, rice, green vegetables); also by KI, large doses of quinin, coal-tar antipyretics, NaCl, alkalies, and the habitual ingestion of large quantities of water. Lithium salts and mineral acids diminish the elimination of uric acid temporarily by rendering it less soluble in the blood; the relief they give is transient and they eventually do harm.

The most marked increase of uric acid occurs in leukemia: up to even 8 gm. daily. An excess is also noted in acute fevers and inflammations, dyspneic disorders, phthisis, splenic diseases, malaria, scurvy, pernicious anemia, diabetes, rachitis, abdominal tumors, cancer and cirrhosis of the liver, migraine, *petit mal,* neurasthenia, chorea, and frequently in dyspeptic disturbances. In gout uric acid is diminished before the paroxysms, and increased during and just after.

An absolute decrease of uric acid is met with in chronic arthritis, chronic lead poisoning, progressive muscular atrophy, chlorosis and simple anemias, usually in diabetes, and in most forms of advanced kidney disease and chronic disorders generally.

Murexid Test.—Evaporate a small portion of the urate or uric acid sediment to dryness in a porcelain dish, add a drop or two of HNO_3 to dissolve the residue, stir with a glass rod, and evaporate slowly to dryness. Allow to cool and add 1 or 2 drops of NH_4OH, getting a beautiful purplish coloration due to murexid or ammonium purpurate, $C_8H_4.NH_4.N_5O_6$. On adding now a drop of NaHO the color changes to reddish blue and disappears on heating. The test can be rendered more delicate by holding a dish of urine and acid over another dish in which a dry NH_4 salt is volatilized (S. E. Earp).

Gravimetric Estimation (Heintz).—This simple, but not very accurate test is made by adding to 200 c.c. of filtered urine, free from albumin, 10 c.c. of HCl, letting stand in a cool place for twenty-four hours, collecting the precipitated uric-acid crystals on a dried and tared filter-paper, washing once or twice with cold distilled water, drying at 100° C., and weighing.

Volumetric Method (Hopkins).—This depends on converting all the uric acid and urates into ammonium urate, which is decomposed by HCl and the separated uric acid estimated by titration with n/$_{20}$ $KMnO_4$ (standardized each time against hot decinormal oxalic acid containing a little H_2SO_4), each c.c. of which is equivalent to 0.00375 gm. of uric acid.

Saturate 100 c.c. of urine with NH_4Cl (about 35 gm. usually necessary), let stand for two hours or longer with occasional agitation, filter, and wash ppt. three or four times with saturated solution of NH_4Cl. Then wash off the pptd. urate with a jet of hot distilled water into a small beaker, and heat just to boiling with excess of HCl. Cool and let stand for at least two hours to allow uric acid to separate completely; filter and wash crystals with cold distilled water.

Now wash the uric acid of the filter with hot distilled water, add Na_2CO_3, warm until the acid is dissolved, and make up solution to 100 c.c. Transfer to a flask, mix with 20 c.c. of concentrated H_2SO_4, and titrate at once with the n/$_{20}$ $KMnO_4$, which should be added slowly toward the end of the reaction, as shown by a transient pink coloration. To the final result, calculated in mg., 1 mg. should be added for each 15 c.c. of fluid in the last filtrate (need never be more than 20 or 30 c.c.), not taking the washings into account.

When there is an abundant deposit of phosphates, these should be filtered off after complete pptn. by heat. The presence of albumin makes it necessary to continue digestion with HCl longer in order to form the soluble acid albumin. If the urine contains much pigment, this should be removed from the urate ppt. by treating thoroughly with alcohol, and after acidulating heating the filtrate gradually to boiling and digest for some time on a water-bath, and then washing the separated crystals thoroughly.

Centrifugal Estimation (Cook).—To 10 c.c. of urine add 1 gm. of Na_2CO_3 and 1 c.c. of NH_4OH. Shake till the carbonate is dissolved, centrifugate earthy phosphates, and pour off clear liquid into another tube. Add 2 c.c. of NH_4OH and 1 c.c. of ammoniated $AgNO_3$ (dram to ounce), and separate silver urate as gelatinous urate, centrifugating until the reading is constant. One-tenth c.c. of ppt. represents 0.001176 gm. of uric acid.

This method is accurate and very convenient. In addition to uric acid it ppts. the other alloxuric bodies, particularly the xanthins. To separate the latter, after getting the centrifugal sediment as above, transfer it to a smooth filter and wash with water till free of silver. The filter is now punctured and the ppt. washed into a liter-flask with 600 to 800 c.c. of water. The contents of the flask are acidulated with a few drops of HCl and then saturated with washed H_2S, boiled and quickly filtered through a small filter, and the Ag_2S ppt. washed with boiling water. The filtrate is evaporated over a naked flame and then to dryness on the water-bath. The residue of alloxuric bodies is now treated with 25 c.c. of 1 to 30 H_2SO_4, heated to boiling over a small flame,

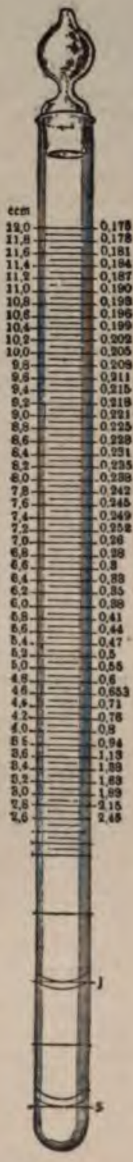


Fig. 76.—Ruhemann's Uricometer. (*Lenhartz.*)

and let stand for twenty hours. The acid dissolves the purin bases, but not uric acid: these are now separated by filtration and washing with the diluted H_2SO_4. The filtrate, containing the xanthins, may be tested by the centrifugal method given above, or by pptg. with ammoniacal $AgNO_3$, incinerating, dissolving in a little HNO_3, and titrating with standard NH_4CNS solution. One part Ag is equivalent to 0.7381 gm. of alloxuric bases calculated as xanthin.

Uricometric Estimation.—The estimation of uric acid with Ruhemann's modified buret uricometer depends on the union of uric acid and I. CS_2 is poured in to the mark S, and an I solution (I 1.5, KI 1.5, alcohol 15, water 185) to the mark I. The urine is now added little by little, with vigorous shaking of the mixture, until the primary brown color becomes white, when the parts per mille (0.175 to 2.45) of uric acid are read off directly from the figures at the top of the liquid column.

HIPPURIC ACID.

Hippuric acid, $C_9H_9NO_3$, is normally present in large amounts in the urine of herbivora; in the autophagic condition of inanition, however, uric acid appears. It is a crystalline substance averaging in daily amount in the human urine from 0.5 to 1 gm., and is of no present practical interest. It is formed by synthesis of benzoic acid and glycocoll in the kidneys. It is increased by vegetable foods containing benzoic acid, such as cranberries, bilberries, greengages, etc., and by the administration of benzoic, quinic, or cinnamic acid or toluol. Pathologically an excess is noted in acute febrile diseases, chorea, diabetes mellitus, and hepatic disorders. It is said to be diminished in amyloid degeneration of the kidney and absent in acute and chronic parenchymatous nephritis.

Detection.—Evaporate urine to dryness with HNO_3, heat residue in a test-tube, and note odor of bitter almonds, due to formation of nitrobenzol.

CREATININ.

This is creatin ($C_4H_9N_3O_2$) minus water. It occurs in about twice the quantity of uric acid and is a metabolic product (Long), which occurs in normal amount in the urine of vegetarians, but is increased by a diet rich in meat. It is not appreciably augmented by physic labor. In alkaline urine it is replaced by creatin.

Detection.—$ZnCl_2$ gives a crystalline ppt. $[(C_4H_7N_3O)_2.ZnCl_2]$ of fine needles grouped in rosettes or sheaves. This test may be used quantitatively.

Jaffe's Test for Creatinin.—Treat several c.c. of urine with dilute aqueous picric acid, and add a few drops of dilute NaHO solution. A red color develops, turning yellow on addition of an acid.

ALLANTOIN.

Allantoin, $C_4H_6N_4O$, is found only in a trace except in the urine of the newborn. It is increased by a meat diet and the administration of tannic acid. It reduces Fehling's solution.

AMMONIA.

This amounts (chiefly chlorid and phosphate) in the urine to 0.5 to 0.8 gm. daily (2 to 5 per cent. of total N of urine—up to 10 gm. daily). An increased elimination occurs (mainly as ammonium lactate) from the ingestion of an excess of mineral or aromatic acids, owing to the self-protective action of the body-cells, especially those of the liver. In liver disease with extensive destruction of the glandular elements, the urinary urea is much diminished, being replaced in part by NH_3 and lactic acid. If the N of NH_3 exceeds 10 per cent. of total N in vomiting of pregnancy, this is toxemic (not reflex or neurotic) in origin (Williams). An absolute increase is noted after fermentation of the urine, in fevers generally (acidosis), and in diseases of the liver. It is sometimes greatly increased in carcinoma. A marked increase (1 gm. or more *per diem*) in diabetes forebodes coma. This increase depends upon excessive destruction of body-proteins, and consequent formation of acids.

Estimation of Ammonia in Urine (Austin).—Place 10 c.c. of fresh urine in a liter flask with 400 c.c. of water; add 5 gm. calcined magnesia; connect with Liebig condenser, from outlet of which a glass tube with bulb is introduced below surface of 20 c.c. of $n/_{10}$ H_2SO_4 in an Erlenmeyer flask, and distill for 45 minutes. Then stop distillation, add as much boiling water to urine as will equal distillate, and distill as before for 45 minutes into another 20 c.c. $n/_{10}$ H_2SO_4. Titrate both H_2SO_4 solutions with $n/_{10}$ NaHO. Difference in c.c. between amounts of NaHO used in first and in second titrations, multiplied by 0.0017, equals amount of ammonia. In the first distillation both free and combined ammonia and decomposed urea come over—in second, only urea.

Volumetric Determination of Ammonia.—To 10 c.c. of the urine in a small beaker add a few drops of phenolphthalein indicator (1 per cent. in dilute alcohol), then 3 or 4 gm. potassium oxalate, and stir till dissolved. Now titrate with $n/_{10}$ NaOH till a faint pink color results. The number of c.c. of alkali required times 10 equals the urinary acidity (normally 30° to 40°). Two or 3 c.c. of formalin solution (commercial product diluted with an equal volume of water, and rendered faintly alkaline with $n/_{10}$ NaOH, using phenolphthalein as an indicator) are now added, discharging the pink color by liberation of acids from ammonium salts. Titration is performed as before, until the pink color just reappears. Each c.c. of $n/_{10}$ NaOH required for the second reaction represents 0.00068 gm. ammonia; multiplying by 10 gives the percentage (normally about 0.05), and the daily quantity is easily calculated if we know the per diem passage of urine.

ENZYMES.

Variable traces of pepsin and rennin are found in the urine, the maximum being four to six hours after meals. The ferments are said to be diminished or absent in gastric carcinoma. The urine seems normally to contain diastatic ferments. Lipase has been found in certain diseases of the pancreas.

CALCIUM OXALATE.

From 2 to 5 decigrams of oxalic acid is excreted daily in normal urine, chiefly as CaC_2O_4. When in excess this is pptd. as octahedral or dumb-bell crystals. An excess usually signifies deficient oxidation, oxalic acid being an intermediate product in the degradation of dextrose. On the urine standing the crystals may form from urates and uric acid.

The daily output of CaC_2O_4 is increased by gelatin, collagen, onions, tomatoes, beets, rhubarb, spinach, sorrel, cauliflower, celery, carrots, beans, asparagus, apples, pears, grapes, pease, cabbage, claret, tea, and effervescent drinks. An excess is also observed in defective digestion of fats and carbohydrates (flatulent and nervous dyspepsia); in malassimilation, the gouty habit, cancer, tuberculosis, diabetes mellitus, organic liver and pancreatic disease, diseases of heart and lungs, rickets, epilepsy, catarrhal jaundice, and convalescence from serious diseases. Oxaluria ("false Bright's disease"), manifested by vesic tenesmus and pain across the back, sometimes extending down the thighs or into the testicles, often accompanies spermatorrhea, sexual neurasthenia, and functional melancholia or hypochondriasis.

CaC_2O_4 is normally held in solution by NaH_2PO_4. When this is transformed to the neutral or alkaline phosphate, crystals of oxalate are thrown down. A milk diet is said to prevent pptn. of calcium oxalate. Oxaluric acid occurs in traces as the NH_4 salt, $NHCOCOOHNH_2CO$.

BILE-SALTS.

The biliary acids are present normally (Purdy) in the urine to the extent of 0.12 gm. daily. They are increased by active muscular exercise and diminished after meals. Pathologically an increase is noted in most blood diseases, malaria, and particularly in liver disorders, especially the decline of bilious attacks (obstruction in hepatic ducts). A decided and persistent decrease takes place in chronic interstitial nephritis. If urine is free from cholates (Austin), sublimed S remains on its surface; if they are present, it sinks rapidly to the bottom.

Estimation.—Oliver's test solution consists of ½ dr. of powdered pepton, 4 gr. of salicylic acid, ½ dr. of acetic acid and 8 oz. distilled water, repeatedly filtered till quite transparent. It reacts to 1 part in 10,000 or more. To make the test the urine must be made perfectly clear (by filtering or shaking with magnesium fluid), be rendered acid, and have its sp. gr. reduced to 1.008. Twenty m. of the urine are added to 60 m. of the test solution. If bile-acids are present in normal quantity, no immediate reaction occurs, but in a few minutes the urine becomes faintly opalescent. An excess is indicated by the immediate appearance of a distinct milkiness. The test can be made approximately quantitative by mixing equal parts of the test solution and of normal urine as a standard. A urine, for instance, of which 10 m.

with 60 of the test solution produces the same degree of opacity as the normal standard mentioned, contains six times as much bile-salts as normally.

MUCIN.

A small quantity of mucin is present in all urines, especially that of women, from vaginal admixture. An excess shows infectious or toxic nephritis, or irritation or inflammation of the genito-urinary tract below the kidneys, by abnormal products (jaundice), concentrated urine or urinary crystals, or following anesthesia. Mucinuria often precedes albuminuria in fevers. Excessive amounts, with abundance of epithelium, are encountered in cystitis, making the urine slimy and viscid.

Detection.—Mucin is pptd. in light-colored threads by vegetable acids or quite dilute mineral acids. The test is made more delicate by treating with alcohol for several hours, and acidifying the filtrate with acetic acid. On shaking mucinous urine (after clouding with acetic acid) with chloroform or ether, a cloudy ring of mucin forms at the plane of contact after the liquids separate.

NUCLEOALBUMIN.

Normal urine, says Simon, contains a trace of simple proteid, and small quantities of nucleic and chondroitin-sulphuric acids, and occasionally taurocholic acid. These acids combine with simple proteid, forming "nucleoalbumin," which is pptd. by acetic acid, like mucin. Unlike mucin, on boiling for an hour with dilute HCl, it yields H_2SO_4 as well as a reducing substance. It indicates epithelial degeneration, and is increased in urine containing bile.

COLORING MATTERS.

These are, in general, best distinguished by the spectroscope. Normal urobilin, $C_{32}H_{40}N_4O_7$, and its impure derivative, urochrom, are the chief coloring matters of the urine, amounting to about 4 gm. daily. They may originate either from bile or blood-pigment. They are somewhat resinous and not very soluble; hence they are removed to some extent by simple filtration. They are increased whenever destruction of red corpuscles is augmented, as in fevers generally, chiefly by bacterial action in the intestines, excessive intestinal putrefaction, internal hemorrhages, heart and liver diseases, typhoid and septic conditions, scurvy, hemophilia, and progressive pernicious anemia. A decrease is noted in diabetes, P poisoning, chronic nephritis, anemia, chlorosis, nervous disorders, extra-uterine pregnancy, and convalescence. They may be absent in total obstruction of bile. Urobilin exists in the urine as urobilinogen, which darkens to urobilin on adding mineral acids and on exposure to light.

Detection of Urobilin.—Acidulate 10 c.c. of urine with a few drops of HCl, shake with half as much amyl alcohol, and add a few drops of 1 per cent. alcoholic solution of $ZnCl_2$ rendered strongly alkaline with NH_4OH. A beautiful green fluorescence appears.

Rosenbach adds one drop only of 5 per cent. solution of CrO_3, getting a pure green color. Urobilin when in excess gives a broad absorption band in the extreme right of the green—between blue and green.

Detection of Urochrom.—Ppt. from solution with ammonium sulphate and decompose with an acid, yielding a brown or black substance.

Uroerythrin (purpurin, rosacic acid) is an amorphous, brick-red, iron-free substance, formed by oxidation of urochrom and usually in combination with uric acid. The pink or reddish color of urates in deposits is due to uroerythrin. Its solution is decolorized by light and is colored dark-green by an alkaline hydrate. An increase of this substance is observed in malarial fever, pneumonia, erysipelas, and hepatic cirrhosis or cancer.

Pyrocatechin is commonly found in the urine as a result of intestinal putrefaction, and causes the urine to darken on standing. Its presence is shown by boiling with HCl, extracting with ether, evaporating, and testing with $FeCl_3$. A dark-green color appears, turning violet on adding a little Na_2CO_3. It is derived from pyrocatechinic acid, present in many plants.

GLYCEROPHOSPHORIC ACID.

$C_3H_9PO_6$ is derived from nervous tissue and amounts normally to 20 mg. daily. It is increased in nervous and febrile disorders and after chloroform anesthesia. Oxyproteic acid, $C_{43}H_{82}N_{14}O_{31}S$, is said to constitute 2 to 3 per cent. of the total N excreted in the urine. Glycocoll (von Noorden) is normally present in all urine (up to 1 per cent. total N).

GASES.

The gaseous constituents of the urine amount to about 16 per cent. by volume, of which nearly $\frac{8}{9}$ is CO_2, and $\frac{1}{9}$ N, with very little O. The passage of air with urine may depend on mechanic introduction, as in the knee-chest position of cystoscopy or during irrigation. Enlargement of the prostate and urethral stricture favor pneumaturia, the diagnosis of which is made certain by having the patient urinate into water. The amount of CO_2 may be greatly increased by yeast fermentation (diabetes), and by the presence of colon bacilli or B. aërogenes capsulatus. In congenital, traumatic or necrotic vesicoenteric fistulas the foul odor of H_2S and of feces is noted, and the exploring sound may be blackened. Certain bacteria may infect the bladder (cystitis) and lead to generation of H_2S therein. All urines on exposure to the air develop H_2S.

ABNORMAL CONDITIONS.

ALBUMINURIA AND GLOBULINURIA.

True or renal albuminuria is persistent and usually considerable in amount. It is nearly always accompanied by casts, anemia, dropsy, or uremia. The access of the circulating proteins to the urine is attributable chiefly to impaired nutrition of the renal cells, due, in the first place, usually to chemic irritants (lead, alcohol) or toxins. Under this division come acute and chronic parenchymatous nephritis (large amount), chronic interstitial nephritis (small amount; sometimes absent), active and passive renal congestion (small quantity), amyloid degeneration (globulin sometimes exceeds albumin), malignant growths (small or moderate amount), renal cysts (5 to 30 per cent. by volume), movable and floating kidney and hydronephrosis (small amount in all), and the passage of excess of uric acid or calcium oxalate crystals or urates. In severe renal disease the ratio of albumin to globulin is about 2.5 : 1.

Functional, or "physiologic," albuminuria is small in amount, transitory, and intermittent, in apparently healthy, but often neurotic, persons. It is rarely accompanied by hyaline casts. Common causes of this form are cold baths; severe mental or muscular exertion (bicycling); violent emotions; eating eggs, cheese, or meat to excess, and following anesthesia. Concentrated urine with or without a deposit of uric acid or calcium oxalate is frequently accompanied by a little albumin and a few cylindroids. In the cyclic, periodic, static, or postural, variety of albuminuria the albumin disappears from the urine at night or during rest, recurring after meals or exercise. It is most often observed in male adolescents, and is attributed to renal congestion due to the erect posture or to floating kidney. A trace of albumin is present for the first few days after birth, and in persons dead for some hours any retained urine may contain albumin from the macerated bladder-walls.

Albuminuria of nervous origin is usually slight, and may be temporary or permanent. It is observed from high blood-pressure after epileptic attacks; also in surgical shock, cerebral hemorrhage, exophthalmic goiter, lead colic, mental strain and worry, concussion of the brain, acute intestinal obstruction, mania, delirium tremens, tetanus, and even occasionally in migraine and menstruation (reflex).

The circulatory form of albuminuria is usually slight in amount, and is most commonly due to passive congestion of the kidneys, as in organic heart disease and great weakness, or hepatic cirrhosis, pleuritic effusions, or emphysema. The same type is exemplified in compression of the renal veins by tumors, the enlarged spleen (hypostatic albuminuria), or the pregnant uterus. It is also seen in sudden exposure to cold and wet and in arteriosclerosis. In renal embolism the albuminuria is sudden and pronounced, with hematuria, disappearing gradually in a few days. Severe diarrhea leads to albuminuria through dehydration and degeneration of renal epithelia.

Obstructive albuminuria is accompanied by temporary or permanent oliguria. A common cause of this type is impacted calculus, which is manifested further by aching pain in the loin, crystals and concretions, and bloody urine. Another cause is twist of the ureter by a displaced kidney, in which there is also severe paroxysmal pain like renal colic. Other causes of this nature are peritonitic adhesions, pressure on a ureter by a tumor or the pregnant uterus, and the uric acid infarcts of infants.

The hemic type of albuminuria depends on abnormal blood-changes, and, in addition to all the blood diseases, includes malaria, jaundice, obesity, diabetes mellitus (irritation of sugar), gout, syphilis, nutrient enemata and intestinal autointoxication (disappears rapidly under intestinal antiseptics), and severe stomach diseases (late stage cancer; gastrectasia). Absorption of pleural effusions is often accompanied by slight albuminuria (with excess of chlorids). The toxins from an abnormal ovary may cause slight albuminuria during menstruation.

Toxic albuminuria represents the local irritant action of chemicals in the blood on the kidneys; it is often attended by bloody or discolored urine. The most common agents giving rise to this symptom are turpentine, cantharis, saltpeter, carbolic and salicylic acids, tar, creosote, iodin, lead, arsenic, mercury, alcohol, phosphorus, ether, chloroform, morphin, mineral acids, ammonia, and carbon monoxid. Pelletierin, used as a remedy for tapeworm, has set up albuminuria with casts.

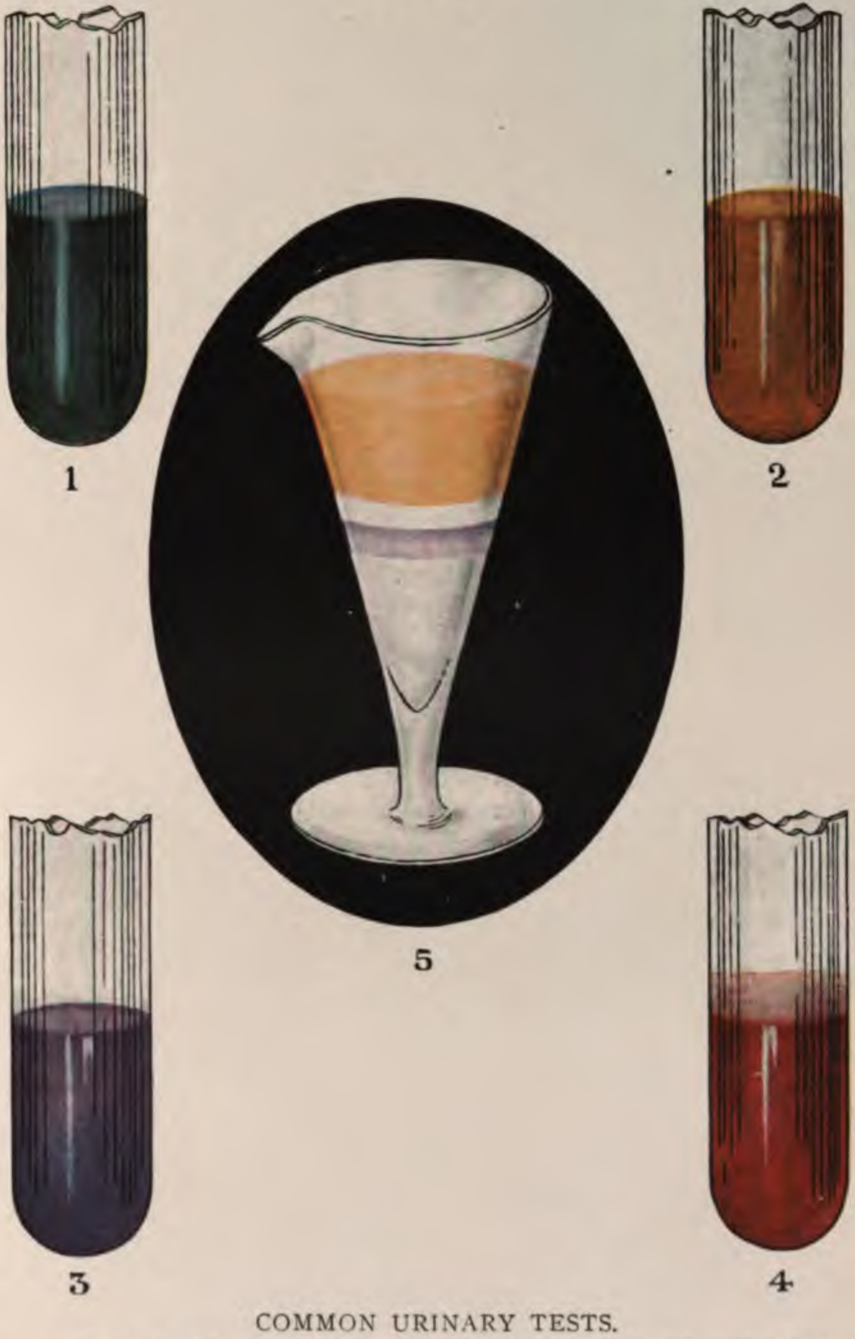
In the febrile type of albuminuria the hemic, toxic (toxins), and circulatory forms are combined. We find albuminuria in nearly all acute inflammations and infectious fevers, especially scarlatina, in which albuminuria is post-febrile and due to acute nephritis. In diphtheria there is a nephritis during the attack. Albuminuria often accompanies tonsillitis. In appendicitis it indicates toxic absorption.

False or adventitious albuminuria is due to the presence of pus or blood from any part of the urinary tract, or to semen, prostatic fluid, or vaginal discharges. In pyelitis there is often considerable albumin (more than is accounted for by the pus in the urine): a distinction from cystitis. Albumin from leucorrhea is readily excluded by catheterization.

Qualitative Tests for Albumin and Globulin.—Formaldehyd in the urine may simulate albuminuria in any of the ordinary tests. When urine is not rendered clear by simple filtration, make turbid filtrate distinctly alkaline with KOH, add a few drops of magnesia mixture (1 part each NH_4Cl, $MgSO_4$ and strong NH_4OH, and 8 parts distilled water), warm slightly and filter through a new paper.

Roberts's Contact Test.—Fill a clean wineglass one-half with

PLATE IX.



COMMON URINARY TESTS.

Figure 1 shows the blue color due to blood in the urine, after treating with alcoholic guaiac and ozonized ether. Figure 2 shows the reddish-yellow precipitate in the copper reduction test for sugar. Figure 3 represents the sodium nitroprussid and ammonia reaction for acetonuria. Figure 4 shows the Ehrlich diazo-reaction in a case of typhoid fever. Figure 5 represents the nitric-magnesian contact test for albuminuria—albumin is shown by the white zone, with a color ring of indican (in excess) below.

clear or filtered urine. Incline the glass and slide under the urine about half as much of the nitric magnesian fluid (1 part of strong HNO_3, 5 parts of saturated $MgSO_4$ solution), and let stand, if need be, for fifteen minutes. If albumin is present (1 to 50,000 or less) a white band will appear exactly at the junction of acid and urine. This zone is sharply outlined above and below, and appears best against a dark background. The width of the band depends mostly upon the degree of admixture of the two fluids, and is not so much a criterion of quantity as is its density. When there is a relative excess of uric acid a light-colored ring is to be seen at a little distance above the line of junction, or the whole layer of urine may become turbid. Excess of mucus is manifested by a diffuse irregular cloudiness in the upper part of the urine. Various colorings (blue or red from indican; red from uroroseinogen; red-brown from iodids) are often to be seen about the line of contact. The test is one of the best for routine examinations, though it also gives a white zone with alkaloids, resinous medicines (soluble in alcohol or ether), and albumoses (cleared by heat).

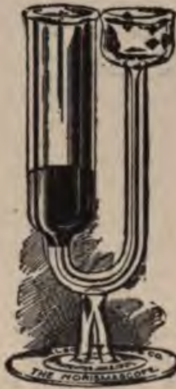


Fig. 77.—Albumoscope. (*Lenhartz.*)

Heat Test.—To a half-filled, wide test-tube of urine add a drop of 10 per cent. acetic acid; if alkaline, add 2 or 3 drops until faintly acid. HNO_3 should not be used, since it would form soluble acid albumin. The addition of one-fourth as much saturated NaCl solution aids considerably in pptg. globulin and keeping mucin in solution. Heat the upper half of the urine to boiling (albumin coagulates about 75°), and note white ppt. if it appears. When due to earthy phosphates this opacity clears up on adding a few more drops of acetic acid, whereas the albumin opacity remains and may become denser. The cloudiness of the upper part as compared with the lower is best discerned against a dark background. Balsamic and resinous acids (copaiba, tolu, turpentine) may give an amorphous ppt. cleared by alcohol. This is the oldest test for albumin, and quite certain. In urgent cases one may boil the urine in a teaspoon.

Ferrocyanid Test.—Mix 1 part 50 per cent. acetic acid and 2 parts 10 per cent. K_4FeCy_6 solution in a wineglass, and carefully overlay with the clear acid urine. A sharply defined white zone at point of contact shows the presence of albumin. This reagent does not ppt. peptons, alkaloids, or phosphates, but may ppt. albumoses and acid urates (cleared by heat). Mucin may react to the acid reagent.

Spiegler's Contact Test for Albumin.—The reagent contains 40 parts of mercuric chlorid, 20 parts of tartaric acid, 100 parts of white

sugar, and 1000 parts of distilled water. If the ring is due to mucin a drop of HCl clears. The test is said to react with 1 part of albumin in 150,000.

Separation of Globulins from Albumins.—Mix urine with an equal volume of saturated $(NH_4)_2SO_4$ or $MgSO_4$ solution (ppts. globulins and albumoses), leaving serum albumin in solution (pptd. only when saturated with above salts). Dissolve first ppt. in 1 per cent. soda solution, and acidulate with acetic acid. Albumoses remain in solution, while globulins are pptd. (ppt. insoluble in NaCl solution).

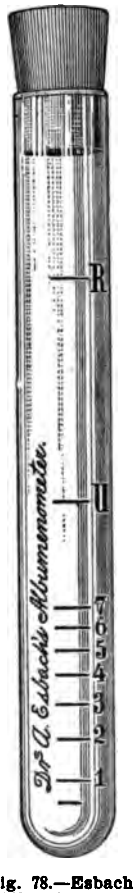


Fig. 78.—Esbach's Albuminometer.

Quantitative Tests for Albumin.

Purdy's Centrifugal Method.—To 10 c.c. of urine add 3 c.c. of 10 per cent. solution of potassium ferrocyanid and 2 c.c. of 50 per cent. acetic acid. Set aside for ten minutes, then revolve for three minutes at a uniform rate of 1500 revolutions per minute. The weight percentage is almost exactly one-fiftieth of the bulk percentage.

Esbach Method.—A graduated albuminometer and a standard solution are employed. The solution consists of 10 gm. of picric acid, 20 gm. of citric acid and distilled water to a liter. The albuminometer tube is filled with urine to the letter U, then the test solution is added to R, and the two fluids well mixed. The tube is let stand for twenty-four hours, when the depth of the sediment will show the amount of albumin in gm. per liter. The test is simple, but only approximate in its results, and the solution reacts with most other proteins as well as albumin; also with quinin and antipyrin. The density of the urine should not exceed 1.008. It should be acid (add acetic acid if need be), and be kept at about 15°.

Gravimetric Method.—This consists simply in acidulating 100 c.c. of the urine with acetic acid, filtering, boiling for a half-minute, filtering, drying until the weight of the filter and contents is constant, and then weighing. The test is easy, but consumes considerable time.

ALBUMOSURIA.

This condition indicates perverted metabolism of proteins and has been noted in suppuration, tuberculosis, tertiary syphilis, hemiplegia, carcinoma, diphtheria, double pneumonia, P poisoning, and muscular and renal atrophy; proteoalbumose also in scarlet fever, pregnancy, nephritis, insanity and transitory disorders of nutrition, and after tuberculin injections. Deutero-albumose (pptd. by Esbach's reagent added to boiling urine and allowed to cool; or by Boston-Roberts reagent = 10 saturated $MgSO_4$ and 1 HNO_3) is found in the urine after massage of the prostate in prostatitis or prostatic abscess. True peptons are practically never present in urine.

In emulsion albuminuria the urine appears milky, and shows minute fat-globules with the microscope. The turbidity is cleared by artificial peptic digestion. Boiling causes a heavy ppt. Bence-Jones protein (intermediate between albumoses and true albumins) contains loose S and is always the result of disease of the bone-marrow with high-grade anemia, being due to degeneration of the myelocytes or of myelogenic tumor-cells (multiple myelomata). Histon and nucleohiston, derived from cell-nuclei, may appear in the urine when there is great destruction of leucocytes.

FIBRINURIA.

Without accompanying hematuria, this condition (coagulable urine) is seen only in chyluria and croupous inflammation (tuberculosis, diphtheria) of the urinary passages. Macroscopic fibrinous plugs are sometimes found in the urine of pyelitis and ureteritis. They do not dissolve in hot water, but are acted on readily by pepsin and dilute HCl or by boiling with 1 per cent. soda solution.

Panum's Test for Albumoses.—Render urine highly acid with acetic acid, add an equal volume of saturated Na_2SO_4, heat to boiling, and filter hot. Albumoses (biuret test to confirm) ppt. from the filtrate as it cools. On adding HNO_3 and heating, the ppt. redissolves, to deposit again on cooling.

Test for Bence-Jones Albumin (Boston).—Boil 50 c.c. of urine, strongly acidulated with acetic acid, with an equal volume of saturated NaCl, and filter while hot; if filtrate becomes cloudy on cooling, this form of albumin is probably present. Verify by washing ppt. with saturated NaCl, dissolve in NaHO solution, and boil, while adding 10 per cent. lead acetate drop by drop for a minute, getting a coarsely granular ppt. of black sulphid. This form of albumin coagulates on heating to 50°, clearing up on boiling. It gives the biuret reaction and is pptd. by alcohol.

Test for Histon.—Free urine from albumin by boiling, cooling and pptg. with 4 volumes of 95 per cent. alcohol. Dissolve ppt. in hot water, and let cool. Get rid of uric acid by pptg. with HCl, letting stand four hours, filtering off uric acid, crystallizing and pptg. filtrate with NH_4HO; wash ppt. with water containing a little NH_4HO, and redissolve in diluted acetic acid. If histon is present, this solution should coagulate on boiling, and give the biuret reaction.

Differentiation of Source of Albumin.—In pyelitis the volume of albumin by Purdy's method is greater than the volume of pus and blood; in cystitis the reverse obtains. In hematuric albuminuria the albumin-volume is greater than six times the volume of sedimented blood if from the renal tubules or pelvis; otherwise, less than six times this volume. The number of red blood-cells per cu. mm. of well-shaken urine divided into percentage of albumin by Esbach's method is less than $1/30000$ if albumin is due solely to blood; more than $1/30000$ if albumin is in excess of blood contents. In pyuria 100,000 pus cells (well-mixed daily urine with same volume of staining fluid) equal 1 per cent. by volume (Esbach's albuminometer) of albumin. If the ratio of albumin to hemoglobin is above the proportion of 1 to 16, true albuminuria is also present, and the hemorrhage is probably of renal origin.

TABLE OF REACTIONS OF URINARY PROTEINS. (PURDY.)

	HOT AND COLD WATER.	HOT AND COLD SALINE SOLUTIONS (10 PER CENT. NACL).	SATURATION WITH NACL OR $MgSO_4$.	SATURATION WITH Am_2SO_4.	NITRIC ACID.	COPPER SULPHATE.	COPPER SULPHATE AND AMMONIA.	COPPER SULPHATE AND CAUSTIC SODA OR POTASH.
Albumin.	Soluble in cold, coagulated in hot, water.	Soluble in cold; coagulated in hot, solutions.	Not pptd.	Pptd.	Pptd. in cold; not dissolved by heating.	Pptd.	Blue solution.	Violet solution.
Globulin.	Not soluble in either.	Same as albumins.	Pptd.	Pptd.	Same as above.	Pptd.	Blue solution.	Violet solution.
Proteo-albumose.	Soluble in both.	Soluble in both.	Pptd.	Pptd.	Pptd. in cold; ppt. dissolves with heat and returns on cooling.	Pptd.	Violet solution.	Rose-red solution.
Hetero-albumose.	Insoluble in both; pptd. by dialysis from saline solutions.	Soluble in both; partly pptd., but not coagulated, at 65° C.	Pptd.	Pptd.	Same as proteo-albumose.	Pptd.	Violet solution.	Rose-red solution.
Deutero-albumose.	Soluble.	Soluble.	Not pptd.	Pptd.	Reacts only in presence of excess of salt.	Not pptd.	Violet solution.	Rose-red solution.
Pepton.	Soluble.	Soluble.	Not pptd.	Not pptd.	Not pptd.	Not pptd.	Violet solution.	Rose-red solution

GLYCOSURIA.

The presence of dextrose (and rarely levulose) in the urine may be classified etiologically as artificial, transitory, and diabetic. Artificial glycosuria is produced by excess of carbohydrate food (passing into lacteals), sweet wines, grapes, and confectionery; also by thyroid or suprarenal extract, or antitoxin, and in chronic lead poisoning; in asphyxia; and in poisoning (cellular asphyxia) by phosphorus, coal-gas, chloroform, or ether (inhalations), curare (muscular paralysis), HCN, H_2SO_4, strychnin, Hg, alcohol, excessive cigar-smoking (CO), fusel-oil, uranium salts, $HgCl_2$, amyl nitrite, or nitrobenzol. Phloridzin glycosuria may be due to intrarenal decomposition of phloridzin into phloretin and phlorose (closely related to glucose). The latter is excreted; the former returns into the blood and recombines with sugar to form phloridzin, which is again acted on by the kidneys. The blood can contain only 3 parts per 1000 of sugar. Grape-sugar occurs normally in urine to the extent of about 1 part in 10,000. Levulosuria alone may occur in neurasthenic subjects.

Alimentary glycosuria may be due to partial lack of function of the pancreas. This form of glycosuria is determined by giving the patient in the morning, on an empty stomach, 70 to 100 gm. of grape-sugar in 500 c.c. of tea or coffee, and then testing the urine for dextrose at intervals of two hours. The dextrose is slight or absent after fasting.

Slight or transient glycosuria is noted especially in fat elderly men and women; it is quasinormal (urine high or normal color; little sugar; slight polyuria), and is due to a lowering of the sugar-consuming power (sugar storing) of the tissues, with lack of oxidation. In other forms of non-diabetic glycosuria there is some pathologic agency affecting the glycogen-storing function of the liver, either through the nervous system, the stomach, or the pancreas or by directly attacking the liver. Gouty glycosuria is allied to the alimentary glycosuria of obesity. Senile glycosuria probably depends upon the greatly reduced capacity of the aged body to consume sugar. The form which follows falls and injuries or nervous lesions, such as cerebral apoplexy and cerebral edema, is analogous to the sudden discharge of accumulated liver-glycogen, caused by experimental lesions. In neurasthenia the glycogen-storing function of the liver is permanently depressed, and hyperglycemia and diabetic symptoms may ensue. The influence of boils, ulcers, carbuncles, and many acute infections, particularly malaria and influenza, in causing glycosuria, seems to depend upon the toxins produced in these conditions, and it usually disappears along with the fever. Glycosuria has been noted in Basedow's and in Addison's disease, myxedema, acromegaly, syphilis, and cholera. Glycosuria may complicate diseases of the brain and spine, hepatic cirrhosis, cholera, phthisis, pneumonia and asthma, later pregnancy, and the puerperal state. Transient glycosuria may appear after epileptic and hysteric paroxysms, or any violent emotional attack. Rarely glycosuria complicates an old nephritis.

True diabetic glycosuria is persistent and usually marked (up to 12 per cent.; more than 500 gm. daily), with polyuria, polydipsia, polyphagia, emaciation, and pruritus. It is often accompanied with acetonuria, lipuria, alkaptonuria, and oxybutyria. The most marked lesion known to be capable of producing diabetes mellitus is wasting of the pancreas, particularly interacinar pancreatitis involving the islands of Langerhans. Diabetes is probably due directly to the lack of an enzyme to split dextrose so that it can be finally oxidized to CO_2. The increase in the water is generally in direct ratio to the quantity of sugar present.

Bronzed diabetes, or hemochromatosis plus glycosuria, is manifested by diabetic signs and symptoms, bronze pigmentation of the surface, and the deposit of brownish-black iron-containing (hemosiderin) and yellow non-ferruginous (hemofuscin) granules in the internal organs. It is due to unknown toxic causes which lead to breaking down of the blood-cells and interstitial inflammation of the liver and pancreas. The iron-containing pigment in the tissues is detected by treating with HCl and K_4FeCy_6.

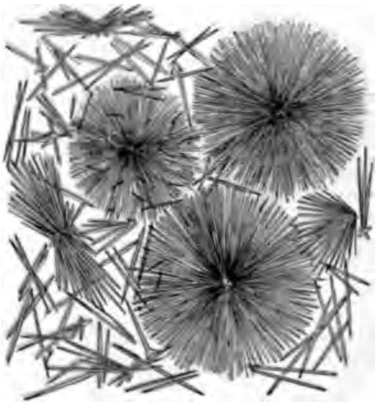
Glucosamin, $C_6H_{13}NO_5$, occurs in combination with mucin or chondroitin. It is a link between proteins and carbohydrates, and may explain the constant elimination of sugar in severe diabetes when no carbohydrates are ingested. It reduces like glucose, has the same osazone, and is dextrorotatory, but does not ferment.

Tests for Glycosuria.

Morphin, strychnin, turpentine, alcohol, amyl nitrite, chloral, chloroform, glycerin, mercury, rhubarb, cascara, salicylates, cubebs, copaiba, arsenic, dilute hydrocyanic or sulphuric acid, acetanilid and other coal-tar products taken by the patient may simulate glycosuria, and formalin or chloroform added to the urine may give a false reaction for sugar.

Haines's Test.—The solution consists of ½ dr. of pure $CuSO_4$ dissolved in ½ oz. of distilled water; ½ oz. pure glycerin; and 5 oz. liquor potassæ. The object of the glycerin is to prevent the precipitation of the copper hydrate that is formed. Take about 1 dr. of the solution in a test-tube, bring it to a boil, and add 6 to 8 drops of the urine while boiling. If glucose is present a yellow or red ppt. is at once thrown down. The yellow appears first and is due to reduction to cuprous hydrate; the red sediment is cuprous oxid. The boiling should not be continued longer than a minute, since uric acid (gray ppt. of cuprous urate) and other substances will reduce copper solutions on prolonged heating or even on standing, giving a greenish opacity. The grayish cloud of earthy phosphates pptd. by the alkali of the solution should not be mistaken for an indication of sugar. The former settle slowly and unevenly, and leave the solution above transparent. Urine having a sp. gr. of 1.030 is best diluted 1:5; if higher, 1:10. If more than

PLATE X.



CRYSTALS OF PHENYLGLUCOSAZONE.

(After v. Jaksch.)

a trace of albumin is present, it should be removed before making the test. This is the best qualitative test for appreciable amounts of sugar in the urine. It reacts with 0.02 per cent. of glucose. Cu_2O is soluble in acids (highly acid urine), NH_4OH and excess of sugar. Test-tubes used for Haines's and Fehling's tests can be cleaned with a little HNO_3.

Fehling's Test.—This older test is preferred by some, though it has a number of disadvantages. The solution contains 34.639 gm. of $CuSO_4$, 500 c.c. of NaHO solution (sp. gr., 1.12), and 173 gm. of c. p. Rochelle salts in enough distilled water to make a liter. Each c.c. of the solution is exactly decolorized by 5 mg. of dextrose (6.7 mg. lactose). The tartrate serves the same purpose as the glycerin in Haines's test, and reduction takes place in the same manner. The copper solution and the Rochelle-and-soda solution are best kept separate till used, mixing equal parts and adding the urine drop by drop till a quantity equal to the mixed reagent is added. Fehling's solution is reduced by sugar, uric acid, glycuronic acid, alkapton, creatin, hippuric acid, carbolic acid, alkaloids, etc.

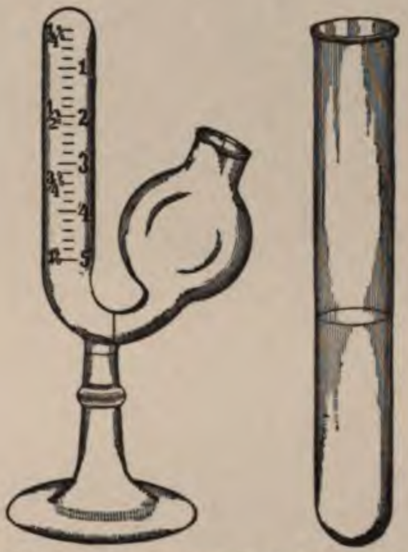


Fig. 79.—Einhorn's Fermentation Saccharometer. (*Lenhartz.*)

Böttger's Test.—Bismuth salts are likewise reduced to the metallic state by sugar in the presence of alkali. Add to the urine an equal volume of liquor potassæ and then a little subnitrate of bismuth. On boiling the mixture turns gray or black according to the amount of sugar present. Traces of S cause a similar reaction; hence the test is not applicable in albuminous urine. It also reacts with glycuronic acid, excess of indican and mucin, but not with alkapton. The sugar reaction is simulated by the ingestion of rhubarb, senna, quinin, salol, turpentine and antipyrin. Nylander's solution ($2BiONO_3$, $4KNaC_4H_4O_6$ and 100 8 per cent. NaHO) is preferable to Böttger's. One part of Nylander's reagent added to 9 parts by volume of urine, and the mixture boiled for a time, shows gray-black to deep black, reacting with as little as 0.05 per cent.

Mulder-Neubauer Test.—Render urine in test-tube strongly alkaline with Na_2CO_3, then add just enough indigo-carmin solution to give a distinctly blue color. Heat the liquid quietly to boiling. In the presence of sugar the color turns green, then wine-red, then yellow. Allow to cool. On shaking well, the color changes back through wine-red and green to blue.

Fermentation Test.—Fill the saccharometer (an inverted test-tube will answer) with the urine after mixing well with a little lump of fresh yeast (and acidifying with tartaric acid). Let stand in a warm place (opt. temp. 34°) for twenty-four hours and notice whether any gas (CO_2) has collected in the upper part of the instrument. The test is very certain when there is considerable glucose present, but unfortunately does not show any result with less than 0.5 per cent. of sugar, owing to the fact that water absorbs its own volume of CO_2. Some specimens of yeast evolve gas spontaneously; hence it is well to use two tubes, one as a control experiment with water.

To utilize the fermentation method quantitatively Roberts directs to fill two 4-ounce bottles with the urine, put a lump of yeast in one, cork this bottle loosely and the other tightly, and keep both bottles in a warm place (80° to 90° F.) for twenty-four hours. Then filter both urines and take their sp. gr. The difference in density represents chiefly the CO_2 given off from fermentation of the sugar, and each degree of loss in weight is equivalent to 1 grain of glucose to the ounce (0.23 per cent.).

Seliwanoff's Test for Levulosuria.—Warm 10 c.c. of urine with 2 c.c. of dilute HCl and a fragment of resorcin, when a red color develops, if positive.

Williamson's Test.—A delicate (0.05 per cent.) and accurate test for glycosuria, and one that does not react with the common reducing agents of normal urine, is the microchemic test with phenylhydrazin, forming beautiful needle-shaped crystals of phenylglucosazone, which are bright sulphur-yellow in color and are arranged singly or in stellate groups and melt at 204° C.

$$C_6H_{12}O_6 + 2C_6H_5.N_2H_3 = C_{18}H_{22}N_4O_4 + 2H_2O + H_2$$

In an ordinary test-tube place ½ inch of powdered phenylhydrazin hydrochlorate, then solid sodium acetate for another half-inch. Half-fill the test-tube with urine and boil for two minutes, the powders passing into solution. Let cool in the rack and examine sediment under rather a low power.

Quantitative Estimation of Glucose.—The best method for medical purposes is that of Purdy. His solution consists of 4.752 gm. of pure $CuSO_4$, 23.5 gm. of KHO, 350 c.c. of strong NH_4OH (sp. gr., 0.9), 38 c.c. of c. p. glycerin, and distilled water to make a liter. The copper salt and glycerin are dissolved separately from the KHO, then mixed, and after cooling the ammonia and the rest of the water added. Thirty-five c.c. of the solution are reduced on boiling by exactly 0.02 gm. of dextrose.

Put 35 c.c. of the test solution in a flask, dilute with about twice as much distilled water, and bring to the full boil. Fill buret to the zero-mark with the urine to be tested, which is run down slowly into the boiling reagent drop by drop until the blue color begins to fade; then still more slowly, 3 to 5 seconds between successive drops, until the test solution is left quite colorless and transparent. The percentage of sugar in the urine is readily calculated by dividing 0.02 by the number of c.c. of urine required to effect decolorization. The test solution is stable and the end-reaction is perfect.

Polariscopic Determination.—Before using the polarimeter the urine should be freed from albumin (levorotatory —56.3°; boil and add acetic acid drop by drop, then filter), if present, and should be practically decolorized by treating with neutral lead acetate or blood charcoal and filtering (see "Polarization" under "Medical Physics"). If levulose accompanies the dextrose, titration gives higher readings than polarization.

Differentiation Tests.—Copper reduction tests react to dextrose, levulose, lactose, pentose, uric acid, creatinin, pyrocatechin, allantoin, alkapton and glycuronic acid. Bi solutions are reduced by dextrose, levulose, lactose, pentose and glycuronic acid. The fermentation test reacts only to dextrose and levulose. Phenylhydrazin yields crystals with dextrose, levulose, lactose, pentose, glucosamin and glycuronic acid. Dextrorotatory are dextrose, lactose, pentose, glucosamin and biliary acids; levoratatory are levulose, β-oxybutyric acid and glycuronates; other carbohydrates are inactive. Phenylglucosazone crystals dissolved in pyridin are levorotatory; maltosazone, dextrorotatory.

LACTOSURIA.

Sugar of milk is occasionally present in the urine of women near the end of gestation and in nursing women, especially when there is obstruction to the flow of milk, as in mastitis; also after weaning and on an abundant milk diet. It is also observed in nursing infants with digestive derangements. It may be accompanied by galactose.

Detection.—If the urine reduces copper solutions feebly, and rotates polarized light strongly to the right, lactose is probably present. The phenylhydrazin test also yields clusters of yellow needles of phenyllactosazone. Lactose may ferment after one hour (glucose under one hour) with compressed brewers' yeast in a warm place.

INOSITURIA.

Inosite, $C_6H_{12}O_6.2H_2O$, is often present in the urine in polyuric conditions, sometimes taking the place of glycosuria. It has also been noted in nephritis, typhus, phthisis, syphilis, and lesions of the medulla.

Detection.—Evaporate with concentrated HNO_3 nearly to dryness on a Pt dish; moisten residue with a few drops of NH_4OH and $CaCl_2$ solution; then evaporate again to dryness. A vivid rose-red color appears with even 1 mg. of inosite.

LAIOSE.

Leo's sugar is occasionally present in severe diabetes mellitus. Like levulose, it is levorotatory, has a reducing action and combines with phenylhydrazin, but it does not ferment and has no sweet taste. Animal gum (achrooglycogen or urinary dextrin) is unfermentable. Normal urine contains a trace of isomaltose.

PENTOSURIA.

Pentoses reduce Cu solutions and form osazones, but do not ferment with yeast. Arabinose, rhamnose, and xylose are the most important. They sometimes appear in the urine after drinking beer or wine, eating pears, grapes, prunes, cherries, and other fruits containing pentosanes, and are likewise found in the urine of morphin habitués (see "Chronic Morphin Poisoning") and in pancreatic disease.

Test for Pentose and Glycuronates (Austin).—Place a pinch of phloroglucin in a test-tube, and add 1 c.c. HCl and heat till dissolved. Now add 10 to 15 drops of suspected urine, heat again to boiling, then let cool. If pentose or glycuronates be present, the mixture becomes red. In the orcin test if the urine gives the reaction at once, pentose is present—if only after splitting, a glycuronate.

ACETONURIA.

This condition signifies, in general, body-fat decomposition, as in advanced diabetes mellitus, infectious fevers, advanced tuberculosis, inanition, carcinoma, eclampsia of pregnancy and extra-uterine pregnancy, death of fetus in utero, excess of fat (especially lower fatty acids) in diet, cyclic vomiting, certain psychoses, strangulated hernia and eclamptic seizures in infants. Other causes are chronic morphinism, P poisoning, leukemia, fatty liver, shock and injuries of the cerebrospinal system, uremia, and following general anesthesia. Disturbances of digestion (autointoxication) and intestinal diseases may also give rise to acetonuria. The normal urine of twenty-four hours contains 1 to 3 cgm. of acetone, and twice as much leaves the body in the expired air. Carbohydrates (von Noorden) tend to lessen the amount of acetone, since they contain much O.

Legal's Test.—Treat ¼ test-tube of urine with a few drops of fresh concentrated solution of sodium nitroprussid, add a few drops of acetic acid (to prevent reaction with creatinin), and render mixture alkaline with NH_4OH. An affirmative reaction is shown by the gradual development of a red color, deepening to purple-red.

Lieben's Test.—Distill 500 c.c. of the urine after adding 0.5 c.c. of H_3PO_4 (to prevent evolution of gases), and use the first 10 c.c. of distillate. To this add a few drops of a dilute solution of iodopotassic iodid and NaHO. In the presence of even a trace of acetone crystals of iodoform are pptd. and are easily recognized by the odor. If diacetic acid is present, remove it first before testing for acetone: Render urine faintly alkaline, then shake with ether (free from alcohol and acetone) in a separatory funnel; shake ethereal solution with water (takes up acetone), then test this aqueous solution for acetone.

Frommer's Test.—Add to urine 2 c.c. of 40 per cent. NaHO, then a few drops of 10 per cent. alcoholic solution of salicylous acid. Warm gently. A deep purple color results if positive.

McGlannan's Test.—Add to the urine excess of 5 per cent. solution of freshly pptd. HgO in 2 per cent. H_2SO_4, filter and boil filtrate. A positive reaction is shown by a more or less marked white ppt.

DIACETURIA.

Diacetic acid, $C_6H_{10}O_3$, is a colorless liquid, turned red by ferric solutions. It is always of abnormal significance, particularly in diabetes mellitus, where its presence forewarns of coma. This compound is also observed at times in fevers, especially in children; appendicitis, pneumonia, pleurisy, pericarditis, scurvy, carcinoma, and diseases of the brain. Diaceturia also occurs as an idiopathic and very fatal autointoxication, manifested clinically by vomiting, dyspnea, jactitation, and coma. As much as 226 gm. have been eliminated in the urine per diem. In decomposing urine diacetic acid takes up a molecule of water and splits into acetone, alcohol, and CO_2.

Von Jaksch's Test.—Add to the urine slowly a rather concentrated solution of $FeCl_3$, filter off the phosphatic ppt. and add more of the iron solution. If a claret-red color appears, boil a fresh portion of the urine and treat another portion with a little H_2SO_4 and extract with ether. If the iron solution gives no reaction with the boiled urine, but gives a claret-red hue with the ethereal extract, diacetic acid is probably present, especially if the urine is rich in acetone. The object in boiling and treating with ether is to exclude antipyrin (red), quinin, thallin, acetanilid (brownish red), sulphocyanates and salicylic, carbolic, acetic, formic and beta-oxybutyric acids. The diacetic reaction is present (Cabot) whenever carbohydrate food is not adequately utilized, because it is not ingested or retained (starvation, prolonged vomiting, rectal alimentation), not absorbed (diarrhea, tuberculoùs peritonitis) or not metabolized (diabetes). It has also been found strongly marked on a salt-free diet.

OXYBUTYRIA.

Beta-oxybutyric acid, $C_4H_8O_3$, is an odorless syrup readily miscible with water, alcohol, and ether. It is an optically active substance, and, if urine is levorotatory ($^{a}\,D = -24.2^\circ$) after fermentation with yeast, it is very probable that this compound is present. The difference between the findings with the polarimeter and with the copper reduction tests represents the amount of $C_4H_8O_3$, or of levulose. Oxybutyric acid can be approximately calculated as three times the quantity of NH_3 in fresh urine.

Oxybutyria is noted (up to 180 gm. daily) in severe cases of diabetes mellitus, often presaging coma; also occasionally in infectious fevers, scurvy, and carcinoma. It is also present (von Noorden) in prolonged fasting. By oxidation on standing, β-oxybutyric acid is changed into diacetic acid, which in turn decomposes into acetone and CO_2.

Test for Oxybutyric Acid (Austin).—Evaporate 100 c.c. of urine to a syrup, add an equal volume of H_2SO_4, and distill without the cooler. Place distillate in a retort with side-tube, and distill into a test-tube packed in ice and salt. If this acid be present, the sides of the tube will be covered with crystals of crotonic acid (from breaking up of oxybutyric acid).

Estimation of Oxybutyric Acid (Darmstaeder).—Render 100 c.c. of urine faintly alkaline with Na_2CO_3, and evaporate almost to dryness on water-bath. Wash residüe into a liter flask with 150 to 200 c.c. of 52 per cent. H_2SO_4, and distill, keeping volume constant by adding water occasionally. When distillate measures 325 c.c., extract several times with ether, which is distilled off, and the residue heated a few minutes at 160°, dissolved in water and titrated with $n/_{10}$ NaHO and phenolphthalein. 100 c.c. of the soda solution represents 0.86 gm. crotonic acid (formed by dehydration); multiply by 1.21 to get β-oxybutyric acid.

ALKAPTONURIA.

The dark-brown color of urine ("alkapton") darkening (to hydroquinone) in air is observed after ingestion of phenol, salicylic acid, and other members of the benzene series. It is also noted as an inherited defect of nutrition, harmless, and lifelong. The latest view is that homogentisic acid, $C_8H_8O_4$ (occasionally mixed with uroleucic acid) is formed in the small intestine as a cleavage product of tyrosin.

Identification of Alkapton.—The urine darkens more quickly on adding $FeCl_3$ or NaHO, and shaking. It emits an aromatic odor and reduces Cu solutions (black ppt.) but not Bi solutions, is optically inactive and does not ferment with yeast.

GLYCURONIC ACID.

This compound ($C_6H_{10}O_7$) is probably (Lenhartz) an intermediate product of metabolism, after either meat or carbohydrate diet; it may be derived from stored glycogen. It occurs in the urine only in combination (glycuronates) with various drugs: chloral, camphor, naphthalene, turpentine, chloroform, morphin, curare, arsenic, copaiba, acetanilid, salol, salicylic acid, sulphonal, urotropin, saccharin, antipyrin, acetphenetidin, thymol, menthol, eucalyptus, glycerin, and nitrobenzol. It is closely related to dextrose, may precede the latter in the urine, and is often mistaken for it.

Identification of Glycuronates.—Glycuronates are to be suspected when there is excessive indicanuria. Urine containing glycuronates is levorotatory, becoming dextrorotatory (glycuronic acid set free) on boiling with H_2SO_4. Glycuronates give a crystalline compound (much lower m.p.—114°—than that of dextrose). This compound reduces Cu or Bi solutions after prolonged boiling, but does not ferment with yeast. It gives the orcin reaction after boiling with 1 per cent. H_2SO_4.

MELANURIA.

In this condition the urine becomes dark or even black on standing or on heating with nitric acid or ferric chlorid, from oxidation of the chromogen melanogen. It is specially significant of melanotic sarcoma in any part of the body, but the pigment may not begin to appear in the urine till the growth is far advanced. Melanin is also sometimes found in the urine in cancer of the stomach, marasmus, inflammations, and severe chronic malaria (microscopic pigment-particles).

Zeller's Test.—Br water causes a yellow ppt. that gradually blackens.

CHOLURIA.

Unchanged bile-pigments in the urine cause it to have a dark greenish-yellow color, with a yellow foam on shaking. A piece of filter-paper dipped in the urine remains yellow after drying. They are present in all diseases accompanied by jaundice (often before the appearance of the yellow hue in the skin), whether from obstruction of the bile-ducts (sometimes by pancreatic disease), disease of the liver (hepatogenous), or decomposition of the blood (hematogenous), as in pernicious anemia, malaria, or typhoid fever, or after internal hemorrhages. Poisoning by ether, chloroform, P or arsin is manifested by choluria.

Rasmussen's Test.—Shake well together 1 c.c. each of urine and ordinary ether with 6 m. of tincture of iodin. On standing the ether and I separate as an upper layer, while the stratum of urine below is colored a brilliant green if biliverdin is present.

Gmelin's Test.—Place a drop of urine on a white porcelain plate, and allow a drop of nitrous or fuming nitric acid to touch and mingle with the other drop. In the presence of bile a play of colors will soon appear in the order of green, blue, violet, red, and yellowish. The green color is indispensable to prove the presence of bile-pigment.

Hay's Test.—Sublimed S placed carefully on the surface of cold urine containing bile pigment settles quickly—slowly or not at all in normal urine. The difference is due to some alteration of surface tension. Alcohol, chloroform, phenol, etc., in the urine simulate bile-pigment in this test.

Baudouin's Test.—Add to the urine in a test-tube 2 or 3 drops of a 0.5 per cent. solution of fuchsin (violet-red), getting, if positive, a fine orange tint.

Hammarsten's Test.—The reagent consists of 1 vol. HNO_3 and 19 vols. HCl, mixed and let stand till yellow; when used, one volume of the combined acid is added to 4 vols. alcohol. In making the test sulphates are first centrifugated out with $BaCl_2$, and the decanted urine is shaken with 2 c.c. of the above reagent, and again centrifugated. According to the amount of bile-pigment, the liquid is colored from greenish-blue to intense green.

Huppert's Test for Bilirubin.—To a few c.c. of the urine add $BaCl_2$ and NH_4HO; wash ppt. with water and suspend in a little alcohol acidulated with H_2SO_4. Boil the mixture for a few minutes, when, if positive, a bright emerald color develops.

Stercobilinuria has been observed in hepatic cirrhosis, chronic malaria, scurvy, pernicious anemia, hemophilia, and after internal hemorrhages; also in febrile and infectious diseases, particularly pneumonia.

CYSTINURIA.

Cystein, $NH_2CH_3SHCCOOH$, is a product of proteid metabolism, never normally found directly in the urine or in the body. It is converted by atmospheric O into cystin, $2CH_3$-$CSNH_2COOH$: a rare urinary sediment.

Cystinuria is a family disease, seen usually in children and young male adults. It has been noted in connection with hepatic disorders, renal degeneration, chlorosis, struma, intestinal putrefaction, and acute articular rheumatism. It is always accompanied by diaminuria originating in putrefactive processes due to specific bacteria in the intestines, and appears to depend on a specific abnormality of metabolism.

CHYLURIA.

Chyle in the urine is a tropic condition, for the most part, and due to the nightly migrations of the filaria sanguinis hominis. The urine in filariasis contains also albumin (coagulates spontaneously) and often blood, which gives a pink color; the parasite may be found in the night urine. Rarely chyluria is brought about by great abdominal compression or by trauma or disease setting up fistulas between the lymph-canals and the urinary channels. The milky appearance (of the night urine in filariasis) is partly cleared by shaking with ether and NaHO. Lecithin and cholesterin commonly accompany the fat.

LIPURIA.

Fat-drops, sometimes forming an oily upper coating on the urine, are occasionally encountered in chronic parenchymatous nephritis, phosphorus poisoning, fatty degeneration of the kidneys, diabetes mellitus, calculous pancreatic disease, acute yellow atrophy, pregnancy (normally), after fractures of the long bones, opening of an abscess into the urinary tract and following the administration of large amounts of fixed oils (rarely form pseudocalculi); also rarely in heart disease, hydronephrosis, gangrene, and pyemia of joints. The fat is readily detected by the microscope and by its solubility in ether. The fat in chyluria is better emulsified, appearing as mere specks.

LIPACIDURIA.

Formic, acetic, butyric, and propionic acids are normally present in urine only in traces (8 mg. per diem). They may be increased ten to twenty times in febrile and hepatic diseases, from intestinal fermentation. Large quantities are formed from urinary carbohydrates during ammoniacal fermentation.

Lactic acid is occasionally present in the urine in cases of deficient oxidation, as in hepatic cirrhosis, acute yellow atrophy, diabetes, leukemia, osteomalacia, rachitis, phosphorus or CO poisoning, and trichiniasis. It occurs in the urine as sarcolactic acid, which is weakly dextrorotatory; its salts are levorotatory. Small amounts of lactic acid have been found in the urine after severe epileptic attacks and in soldiers after marches. Succinic acid has been found in the urine after the ingestion of asparagus.

HEMATURIA.

One part of blood in 1500 makes the urine smoky; 1 to 500, bright-red (chocolate-brown if much acted on by the urine). Blood in the urine is best determined by the use of the microscope. A good chemic test for blood-coloring matter is to add to a few c.c. of tincture of guaiac in a test-tube a few drops of ozonized ether, then underlay the mixture with urine. If hemoglobin is present a blue ring will soon appear at the line of junction of the two fluids. This ring does not disappear on boiling, as does a similar zone due to pus. In the guaiac test for blood the urine should be distinctly acid (acetic). Yeast or milk may simulate.

Spectroscopic Test (Witthaus).—Add excess of 10 per cent. NaHO solution to 200 c.c. of urine; collect ppt., dissolve it in alcohol acidulated with HCl, and examine solution with spectroscope for spectrum of hematoporphyrin (see plate of absorption spectra). If result is negative, ppt. alcoholic solution with NH_4HO, dissolve ppt. in dilute acetic acid, agitate this solution with chloroform, and examine solution with spectroscope.

When the blood is from the kidney the urine appears smoky; the blood is usually slight in quantity, acid, and well mixed, and blood-casts are to be found. From the renal pelvis the blood is generally profuse and well mixed with the urine; this hemorrhage is generally unilateral, as shown by cystoscopy, segregation, or ureteral catheterization, and tailed columnar epithelia prevail. Hemorrhage from a ureter is manifested by long clots, like earthworms in size and shape. There is renal colic in the passing, just as in some cases of tubal or pelvic hemorrhage, and hematuria may alternate with normal urine when the passage is stopped. Blood from the bladder appears in large, irregular, bright-red clots (sometimes dark-brown if urine is quite alkaline) at the end of micturition. If the bladder is washed out with borax solution until what comes away is clear, and the solution is again injected at once, it will come away bloody. Cystoscopy gives definite information as to the cause of the bleeding. Blood from the prostate appears toward or at the end of micturition, which is usually difficult. Bright blood from the anterior urethra is passed at the beginning of micturition and during the intervals, or can be stripped out. From the posterior urethra it is usually slight in quantity and comes at the beginning or end of micturition or both, sometimes clotting. Pink semen indicates a hemorrhage from the seminal vesicles. Blood from the vulva, vagina, or uterus is readily distinguished by the fact of menstruation, by inspection, by washing, and if necessary by catheterization.

The following are the more common causes of hematuria: Trauma, acute nephritis, acute exacerbations of chronic nephritis (sudden appearance of normal blood), localized area of fibrosis in one kidney (hemorrhage may be profuse), active congestion (sometimes from intestinal toxemia), filariasis, embolism, thrombosis, renal abscess (following evacuation), urinary tuberculosis, syphilis, malignant growths (profuse and apparently causeless), polycystic kidney (bilateral tumor), calculi (hemorrhage usually follows exertion; pain on micturition or renal colic; usually pus), renal cysts, floating kidney, blood diseases, irritant drugs (turpentine, cantharis, urotropin), neuropathic angioneurosis, acute infections, vicarious menstruation, pregnancy, lactation, strong mental emotions, uric acid or calcium oxalate infarcts, severe inflammations or ulceration, benign vesic growths (papilloma, myoma, fibroma, myxoma—bleeding profuse), varicose veins at neck of bladder, sudden emptying of dilated bladder or renal pelvis, and the distoma hematobium.

HEMOGLOBINURIA.

The presence of blood-coloring matter without the corpuscles shows extensive destruction of red blood-corpuscles, as in acute infections, purpura, scurvy, syphilis, severe burns, transfusion of blood, absorption of hemorrhagic effusions, Winckel's disease, and poisoning by chloral, $KClO_3$, quinin, I, coal-tar derivatives, glycerin, mushrooms; carbolic, hydrochloric, sulphuric, and pyrogallic acids; phosphorus, and H_3P, H_3As, H_2S, and CO. Hemoglobinuria is also seen in hepatic insufficiency, simple icterus neonatorum, and following exposure to cold or violent physic exertion. So-called idiopathic hemoglobinuria is met with at times in estivoautumnal malaria, Raynaud's disease, and following cold and exertion, and is accompanied by chills, fever, lumbar pains, vomiting, and diarrhea. The urine is scanty, porter-colored, and slightly albuminous, and shows a sediment of brown granules, pale droplets, and brown granular casts. The paroxysms occur at intervals of weeks or months and last a few hours.

Typic hematoporphyrinuria is observed in poisoning from, or after the prolonged administration of trional, tetronal, or sulphonal, and sometimes in plumbism. The urine is dark-red in color, becoming almost black on standing. It turns yellow on adding ammonia, and is bleached by HNO_3. Hematoporphyrin is tested for spectroscopically (after treating urine with $\frac{1}{5}$ its volume of 10 per cent. NaHO, and dissolving ppt. in alcohol containing HCl).

PYURIA.

Purulent urine is cloudy and deposits a creamy (ropy if alkaline) layer. Pus from the kidney tubules is usually small in amount (unless from abscess) and is attended by casts and acid urine. A larger amount is met with when the renal pelvis is involved; the urine is usually acid and the pus settles quickly; micturition may be frequent, but not painful. In vesic pyuria the amount of pus is usually considerable; the urine quickly loses its acidity or is already fetid, ammoniacal, and viscid; and the pus settles slowly and partially; micturition is usually both frequent and painful. The sudden appearance of a large quantity of pus is indicative of an abscess rupturing into the urinary channels. In gonorrhea one can tell whether the inflammation has extended to the posterior urethra by having the patient pass water into two glass vessels. If the first portion only of the urine contains pus-threads (*tripper faden*), infection is restricted to the portion of the canal in front of the "cut-off" muscle, and *vice versâ*. Epididymitis with suppuration is manifested by yellowish or greenish-yellow semen.

Pus from the kidney may be due to tuberculosis, bacterial invasion, trauma, new growth, calculus, pyemic abscess (sudden large quantities of greenish pus), or extension of gonorrhea; prostatic obstruction predisposes to upward extension of any infection. Pus from the ureter usually means the passage of a calculus or the resulting inflammation. Pus from the bladder may be due to prostatic obstruction, gonorrheal stricture, tubercle, calculus, trauma, or new growth. Pus from the prostate depends upon prostatic hypertrophy, gonorrhea, tubercle, trauma, stone, or tumor. Pus from the urethra may be due to simple or gonorrheal urethritis, trauma, tubercle, chancroid, syphilitic ulceration, or malignant disease. Pus milked from the seminal vesicles is usually of gonorrheal origin, but may depend on sexual excesses, tubercle, or new growth. Pus from the uterus or vagina is usually accompanied by much squamous epithelium, and is excluded by catheterization or a thorough vaginal douche. Pus in the urine of infants is most often from the renal pelvis, and, if continued, commonly denotes calculous or tuberculous disease. Donné's reaction is the gelatinization that takes place on adding some solid KHO to a sediment of pus.

PTOMAINS.

Griffiths has isolated special alkaloids from the urine in the following diseases: Parotitis, scarlatina, diphtheria, measles, pertussis, glanders, pneumonia, epilepsy, erysipelas, puerperal fever, eczema, influenza, carcinoma of the uterus, pleuritis, and angina pectoris. Albu has also found toxins in the urine of patients with hectic phthisis, exophthalmic goiter, tetanus, pernicious anemia, diabetic coma, and urticaria due to autointoxication.

MICROCHEMISTRY OF THE URINE.

The presence of an unorganized sediment in urine signifies, as a rule, merely a change in temperature or chemic reaction, owing to which the solvent power of the fluid for the substance pptd. is diminished or nullified. The presence of such a sediment bears no relation whatever to the amount of ingredients in the urine. With the exception of the slight cloud of mucus seen normally in cooled urine, organized urinary deposits are always pathologic. On the whole, however, cloudy urine is a less serious indication than is a very clear renal excretion, such as we see in diabetes mellitus and chronic Bright's disease.

For the accurate study of urinary sediments the microscope is absolutely essential. A centrifugal machine for the rapid settling of casts and other suspended matters must be considered a necessary adjunct to the microscope. With the aid of the centrifuge one gains not only more delicate, but more correct, results, since the urine can thus be examined in a perfectly fresh condition before any chemic decomposition takes place with precipitation of uric acid, calcium oxalate, earthy or triple phosphates, and other secondary sediments resulting from acid or alkaline fermentation.

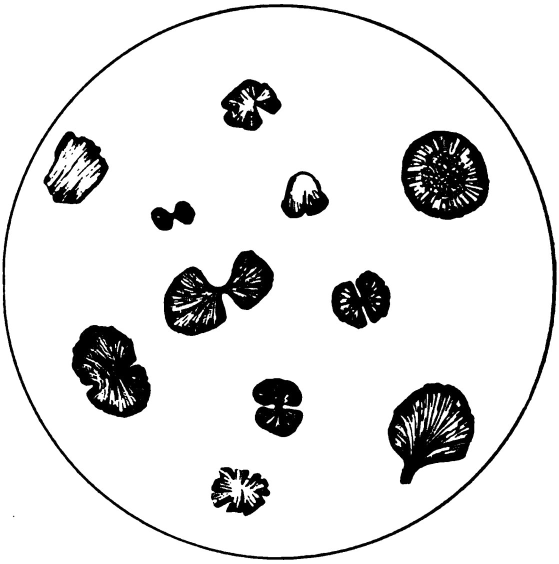


Fig. 80.—Sodium Urate Crystals.

A "shoulder-slide" easily holds 2 or 3 drops of the sediment for microscopic examination. Formed elements and crystals can be stained or tested as to solubility by placing a drop of the staining fluid or solvent on the slide next the cover-glass, and then drawing the liquid under the glass by holding a strip of filter-paper at the other side. To preserve organized urinary sediments (Brooks), decant urine and cover sediment with potassium acetate solution (sp. gr. 1.050 to 1.060) containing 0.5 per cent. of deliquesced crystals of phenol. Let settle again, decant, and treat as before.

CRYSTALS.

The only colored urinary crystals are uric acid, ammonium urate, and rarely cystin and acid urates, hematoidin, leucin, and tyrosin. All these crystals owe their color to urochrom,

PLATE XI.

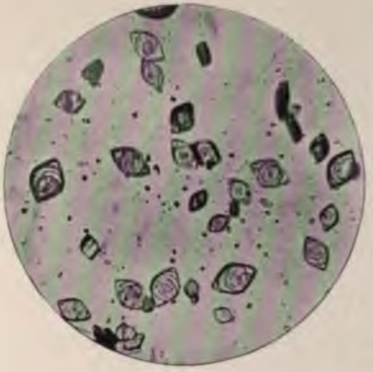


Fig. 1

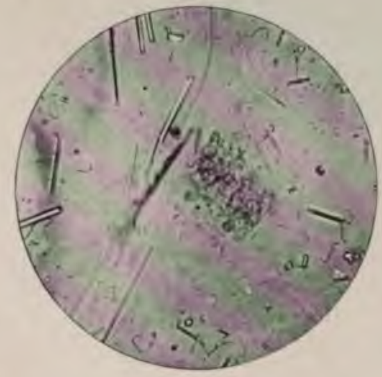


Fig. 2

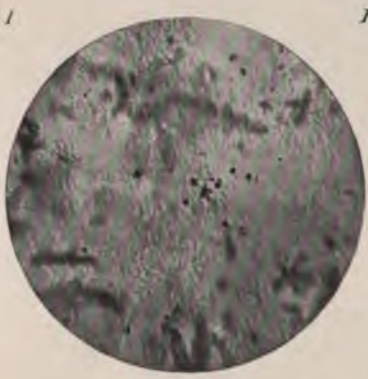


Fig. 3

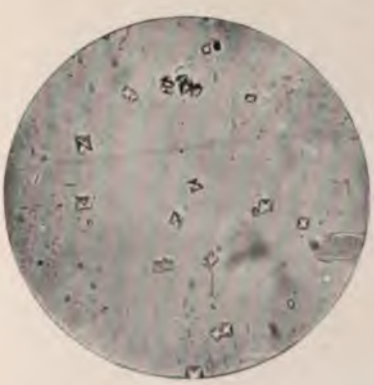


Fig. 4

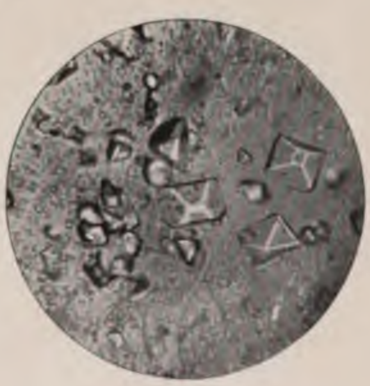


Fig. 5

URINARY CRYSTALS.

and are darker or lighter, according to the amount of this pigment.

Uric acid is pptd. from its normal occurrence as urates by an increase of acidity (excess of NaH_2PO_4), particularly when the urine is of low sp. gr. and deficient in pigment. To the naked eye uric acid appears as a crystalline sediment resembling grains of red sand or Cayenne pepper. Under the microscope it appears as large and beautiful crystals of various forms, the lozenge shape predominating, frequently arranged in a superimposed manner into rosettes and other composite combinations.

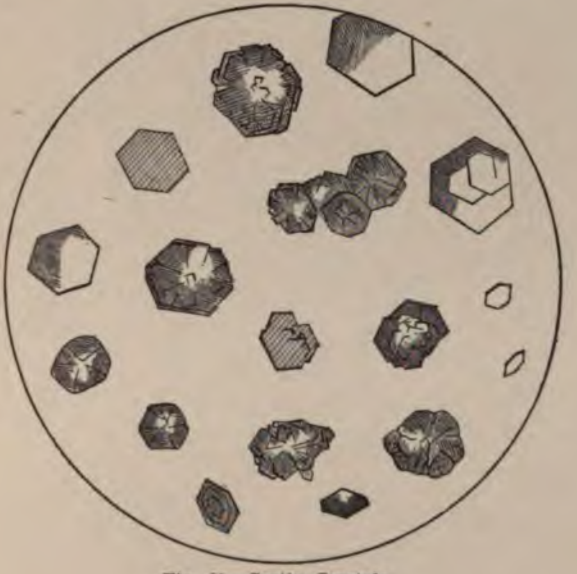


Fig. 81.—Cystin Crystals.

Uric acid crystals are readily distinguished from any other (except urates, bilirubin, and cystin) by their lemon-yellow or red-brown color. They are soluble in NaHO; repptd. by HCl. The rough and pointed forms are suggestive of calculi.

Uric acid deposits are frequently due to excess of meat in sedentary livers and in the excessive catabolism ("uric acid diathesis") of deficient oxidation. They are also observed in fevers, after gouty paroxysms, in the early stage of chronic interstitial nephritis, and during recovery from acute exanthems or acute nephritis.

Acid urates are usually amorphous, but rarely appear as fan-shaped and stellate acicular crystals of a reddish-brown or yellowish tint. Uric acid and urates are readily soluble in alkaline hydrates.

Ammonium urate appears in the urine after it has undergone alkaline fermentation (urine may be amphoteric), and is sometimes seen in the scanty febrile urine of children. It usually takes the form of little brown balls with spicules—the so-called "thorn-apple," "hedgehog" crystals; sometimes a "sheaf of wheat" clump of fine needles with a central spherule, or a pair of dumb-bells. Treated with HCl, it yields uric acid crystals.

Cystin, $(C_3H_6NSO_2)_2$, is rarely met with as a lemon-colored deposit in faintly acid urine. It contains 26 per cent. of S, and on standing for some time is apt to turn of a greenish hue and develop the odor of H_2S. The microscope reveals overlapping, highly refractive "mother-of-pearl" hexagonal crystals (or quadrilateral prisms), which are distinguished from those of uric acid having a similar appearance by treating the specimen on the slide with a drop of NH_4OH. The ammonia is allowed to evaporate, with the result that the cystin crystals remain unchanged, while uric acid crystals are changed to ammonium urate spherules. Cystin is soluble in HCl; uric acid is not. Cystinuria is related to diaminuria, and has been noted in connection with liver disease and acute articular rheumatism.

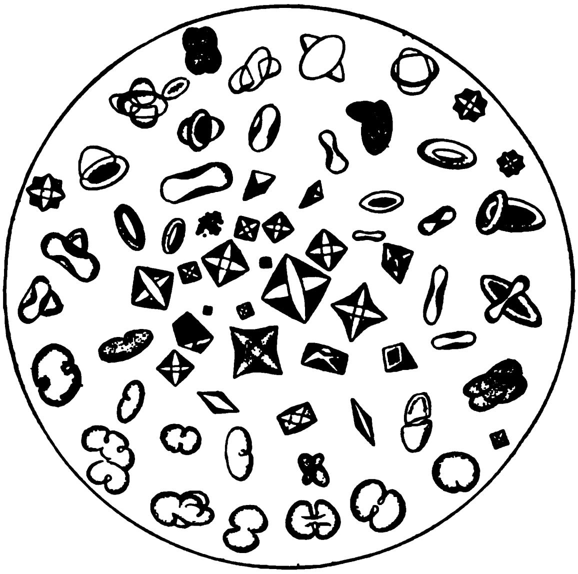
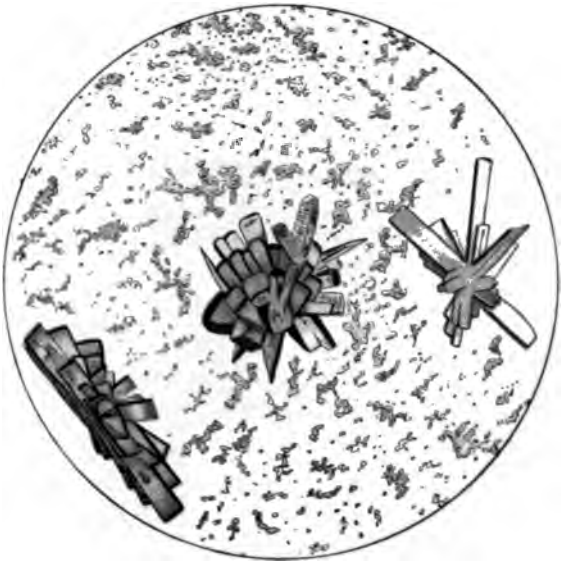


Fig. 82.—Calcium Oxalate Crystals.

Leucin and tyrosin are nearly always associated in the urine, being observed chiefly in acute yellow atrophy and phosphorus poisoning. They may also accompany typhus, smallpox,

PLATE XII.



Uric Acid Crystals with Amorphous Urates.
(After Peyer.)

typhoid, yellow fever, pyemia, gangrene, or alcoholic cirrhosis. The former appears in the shape of somewhat striated yellowish spheres resembling oil-drops, from which they are differentiated by their insolubility in ether. Tyrosin is observed in the form of tufts or sheaves of very fine needles, snow-white when viewed *en masse*. Tyrosin is rarely simulated by soaps of lime and magnesia.

Hoffmann's Test for Tyrosin.—Boil solution or deposit with excess of water, then heat with Millon's reagent, getting a pink or crimson coloration or ppt.

Hematoidin (bilirubin) crystals are often deposited in urine containing bile and following hemorrhages, or the evacuation of an abscess. They appear as yellow or ruby-red needle clusters or rhombic plates, which are soluble in NaHO, and show a green rim on adding a drop of HNO_3. Indigo very rarely appears in the urine as blue needles in stellate form.

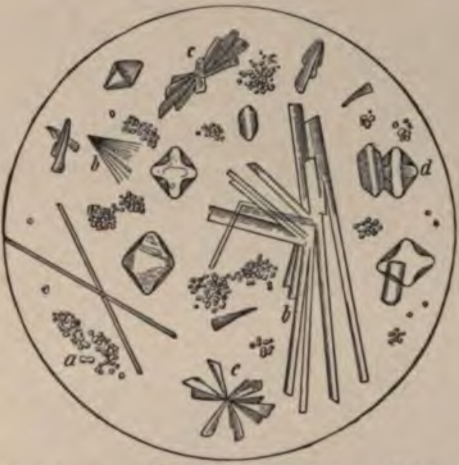


Fig. 83.—(After *von Jaksch.*) (*Lenhartz.*) *a*, Calcium carbonate. *b*, Calcium sulphate. *c*, Neutral calcium phosphate. *d*, Basic magnesium phosphate. × 350.

The colorless crystals of the urine include triple phosphates, calcium oxalate, calcium phosphate, calcium sulphate, cholesterin, calcium carbonate, and fatty acid crystals.

The so-called "triple" phosphate of ammonium and magnesium, NH_4MgPO_4, is seen normally in urine which has undergone ammoniacal fermentation after voiding (urine may be amphoteric). When present in freshly passed urine such a deposit is always pathologic, indicating ammoniacal decomposition within the bladder as both a cause and a result of cystitis. Triple phosphate crystals are relatively large and colorless, having the form ordinarily of a triangular prism with beveled ends;

hence the name "coffin-lid" crystals. Collections of these crystals often form a glistening film on the surface of stale urine and the sides of the container; this appearance, under the designation of "kiestein," was formerly believed to be a sign of pregnancy.

$CaH(PO_4).2H_2O$ crystals are sometimes observed in feebly acid urine as broken, granular plates, wedge-shaped or conic scaly forms, usually grouped in a radiating manner point to point. They are distinguished, like phosphates generally, by their ready solubility in acetic acid (acid sodium urate dissolves more slowly and is replaced by crystals of uric acid). This phosphate also occurs as pale, highly refractive granules in very feebly acid urines. A deposit of this nature is rarely met with in health when the urine is rich in lime-salts, as after a full meal of certain vegetables. Pathologically the deposit has been noted in phthisis, pyloric cancer, calculi, and obstinate chronic rheumatism.

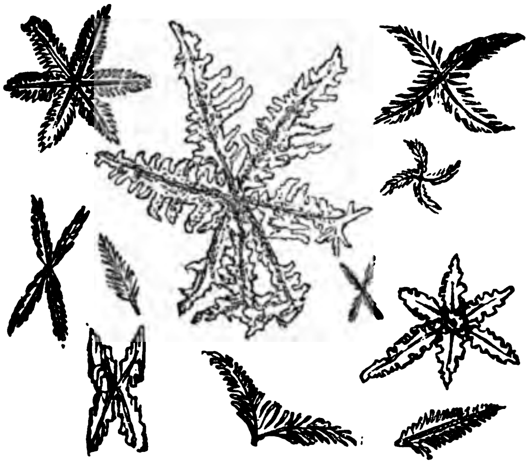


Fig. 84.—Feathery Crystals of Triple Phosphate. X 350. (After *Tyson.*) (*Lenhartz.*)

Trimagnesium phosphate appears in fine feathery crystals. Basic Mg phosphate appears amorphous or in large rhombic plaques, or as thin plates like broken window-glass, from the glistening pellicle on the surface of urine.

Calcium oxalate is rather a common sediment, often mistaken macroscopically for a cloud of mucus, with which, for obvious reasons, it is often co-existent. It is found both in acid and in alkaline urine, being held in solution normally by acid sodium phosphate. CaC_2O_4 crystals are usually octahedral in shape, giving the appearance of a square crossed by two diagonal bright lines, like the back of a square envelope. They are much smaller than those of the triple phosphate, from which they are further distinguished by their insolubility in acetic acid. Much rarer forms of calcium oxalate crystals are those resembling a dumb-bell, the umbrella forms, and the oval and circular (sometimes radiating) crystals with bright centers showing biconcavity. They are rarely colored yellow by bile-pigment, or blue by indican.

CaC_2O_4 is probably formed from uric acid in the kidneys, and may thus replace the acid in part in the urine. The large crystals are thought to be primary: *i.e.,* formed within the body.

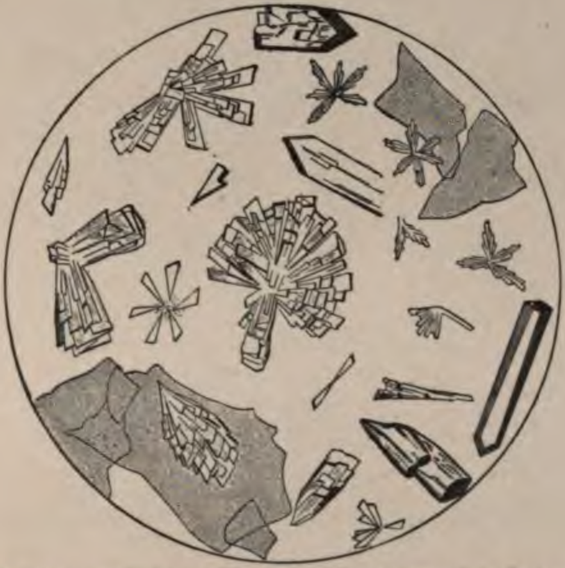


Fig. 85.—Calcium Phosphate Crystals. × 350. (After *Peyer.*) (*Lenhartz.*)

The crystals are sometimes pptd. by neutralizing an acid urine. The number of these crystals depends on the quantity of Ca in the urine, and an excess often accompanies colitis. CaC_2O_4 crystals are found in large numbers in catarrhal jaundice, diabetes mellitus, and azoöspermatorrhea. Their more or less constant occurrence (oxaluria) indicates suboxidation and malassimilation (as in lithemia), high tension, and errors in diet and hygiene.

Hippuric acid is occasionally met with as a slight urinary sediment (after salicylic acid and in diabetes mellitus and liver disease) in the form microscopically of fine needles or of four-sided rhombic prisms with beveled ends and edges. It is soluble in alcohol; insoluble in acetic acid.

Cholesterin—in large, thin, and nearly transparent plates with broken corners—is occasionally encountered in the urine of cystitis, diabetes, chyluria, tabes, pregnancy, jaundice, nephritis, fatty or amyloid or cystic (filariasis, echinococci) degeneration of the kidneys, and after evacuation of an abscess into the urinary tract or the long-continued administration of bromids. Treated with dilute H_2SO_4 and then with I solution, these crystals turn violet, turquoise, then blue.

Calcium sulphate is a very rare sediment, occurring only in acid urine of high sp. gr. The crystals are long, radiating, colorless needles or rods insoluble in acids or ammonia. Calcium carbonate is also an exceedingly rare deposit in the human renal secretion. It is found only in alkaline urine as a whitish deposit that dissolves with effervescence in dilute acids, and which under the microscope is shown to be composed of amorphous material or concretions of little spheroids (sometimes in pairs, like biscuits or dumb-bells), much smaller than ammonium urate.

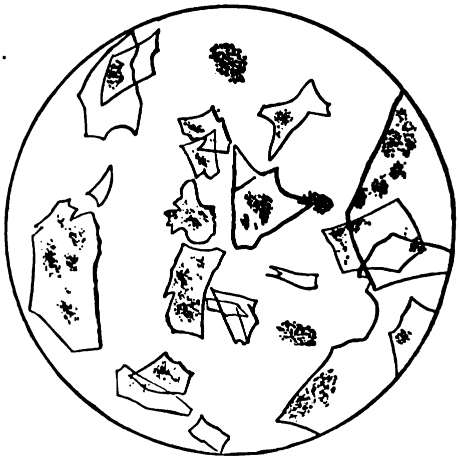


Fig. 86.—Magnesium Phosphate from a Fresh Pellicle upon the Surface of Urine. (*Lenhartz.*)

Fatty acid crystals are sometimes seen with the microscope as fine, bright needles (often rosettes) adhering to fat-drops and fatty cells. They are observed in the large white kidney.

GRANULES.

Acid urates of K and Na are, by far, the most common urinary deposits, forming sediments that are usually amorphous and vary in color from a light pink to a deep red—rarely colorless. Under the microscope they appear as pink, granular, moss-like beds, which clear up on warming or on treating with a drop of NH_4OH. Calcium urate is of rare occurrence as a urinary sediment, appearing as a light-gray, amorphous powder. Like the other urates, it is found only in urine of acid reaction; these mixed urates constitute the well-known "brick-dust" deposit of cold and dense urines. Persistent urate deposits are noted in chronic diseases with hectic fever, in goutiness, and from free indulgence in meats and heavy liquors. The white urates of young infants consist chiefly of amorphous ammonium urate. Urine rich in urates after being in a bottle for some time leaves a very adherent film of these on the inside of the flask. Urates may ppt. in the bladder, owing to reabsorption of the water of the urine; hence holding the urine predisposes to stone. Acid fermentation (vesic mucous catarrh) causes uric sedimentation. Na salts decrease the solubility of sodium acid urate.

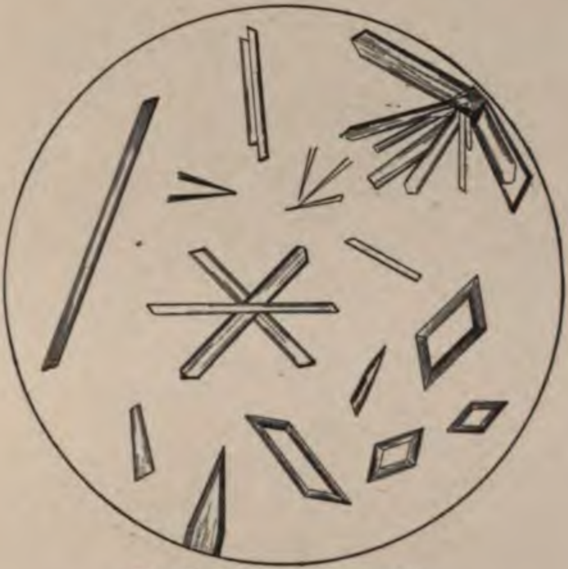


Fig. 87.—Hippuric Acid Crystals.

The normal earthy phosphates (Ca and Mg) constitute the most common sediment of alkaline urines. They are easily soluble in acetic acid, being in this way discriminated from other urinary deposits. The color of a phosphatic sediment is usually gray, but in the presence of hemoglobin has a reddish tinge, and sympexia from the prostate are often colored blue or yellowish. Cloudy urine from these granular phosphates is often seen after a full meal of vegetables, but the constant presence of phosphaturia indicates, as a rule, a low general metabolism.

The black pigment melanin (phymatorhusin) occurs in lumpy, microscopic granules, soluble only in boiling mineral acids or strong solutions of the caustic alkalies.

Irregular masses, or rhomboidal crystals, of indigo are rarely noticed in the urine, especially when this has undergone putrefactive changes with oxidation of indican. The blue particles may also be derived from the underwear.

CASTS.

Tube-casts, or cylinders, are molds of the renal tubules, formed by the transudation of coagulable material, and by exudation from and degeneration of the epithelial cells lining these tubes. The casts contract and entangle formed elements and crystals, and are finally washed out by the pressure of liquid from the glomeruli. They are nearly, if not quite, always accompanied by albumin. On the urine standing, casts are dissolved by the bacteria present, particularly the colon bacilli.

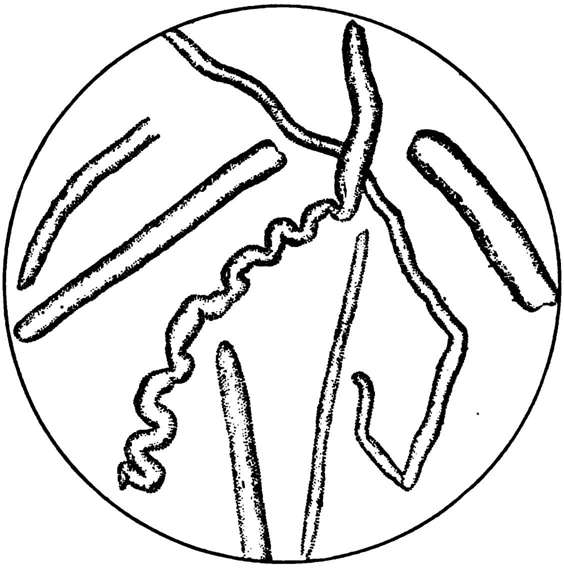


Fig. 88.—Narrow Hyaline Casts.

Tube-casts are of prime importance in the diagnosis and prognosis of renal diseases. Small casts (from the narrow and convoluted tubules) characterize acute and superficial lesions, as a rule, while broad casts (from the straight collecting tubules) are more often observed in well-advanced degenerative cases. Very thick casts, from the collecting tubules, are present in cases of weak heart and scanty urine. Casts are distinguished from foreign bodies by their cylindric, finger-shaped form, often rounded at one or both ends; and by their more regular contour and lesser opacity.

The simplest type of tube-cast is the hyaline, which is so nearly transparent as to require a dim background for its ready detection. These casts are rendered more readily visible by adding a drop of eosin solution to the deposit before putting on the cover-glass. A few hyaline casts, with a trifling amount of albumin, are often to be found in transient renal circulatory disturbances, such as may be caused by a long bicycle-ride, overeating or overdrinking, mental or physic strain, fevers, lithemia, embolism, and ether or chloroform anesthesia. They are also seen in cases of cyanotic kidney, due to passive congestion, amyloid disease, and occasionally in anemia, malnutrition and suboxidation, nephrolithiasis, pyelitis, floating kidney, and even with tumors of the bladder. Jaundice may be accompanied by yellow, hyaline casts. Chronic interstitial nephritis is manifested by the constant or intermittent occurrence of small numbers of hyaline casts, and still fewer, faintly granular ones, along with polyuria and slight albuminuria and distinctive cardiovascular changes.

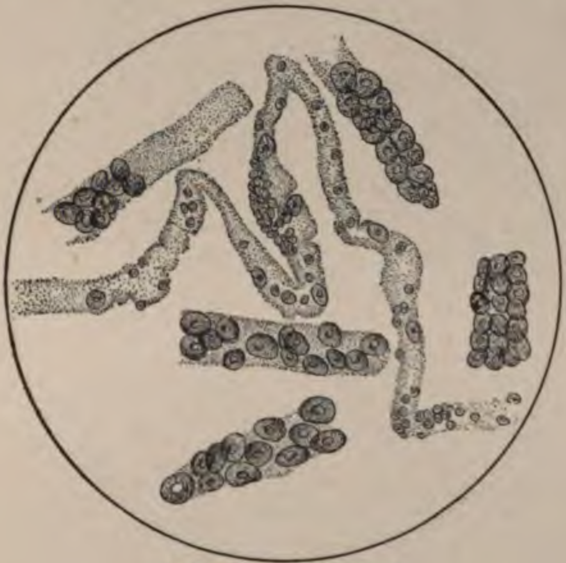


Fig. 89.—Epithelial Casts.

The band-like so-called cylindroids are similar in appearance and nearly equal in significance to hyaline casts, but are very much larger. They are not destroyed in an alkaline urine; true casts are. They are most frequent in pyelitis, scarlet and recurrent fevers, and cholera. Long, pale, branching, striated mucin bands are always present with excess of mucus, and hence are noted in any dense, acid, irritating urine. Cylindroids from the prostatic ducts are usually accompanied by many mucin threads.

Mixed casts, composed of a hyaline matrix, beset with blood- or pus- cells, epithelia, nuclei, or granules, characterize acute parenchymatous or diffuse nephritis, being found here in large numbers; and also the exacerbations of chronic nephritis. The irregular blood-casts proper are likewise noted in renal hemorrhage from any cause, and in small numbers from infarction or marked congestion of the kidney. When retained long in the tubules the corpuscles break down into dark, rusty granules, forming, thus, rarely hemoglobin-casts. Rarely in severe renal congestion hollow cylinders of epithelium are thrown off.

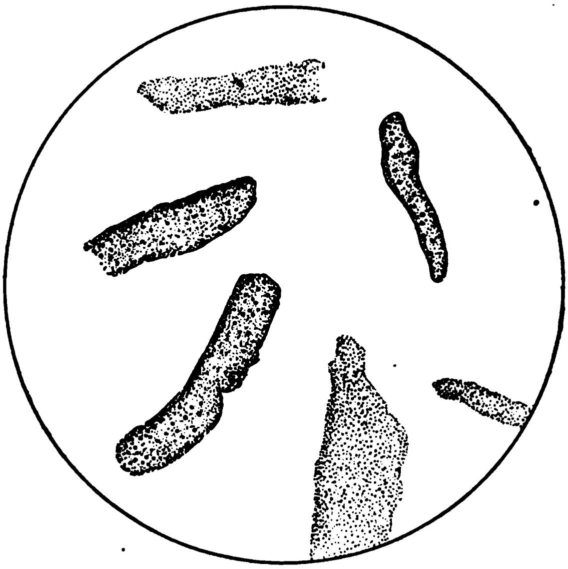


Fig. 90.—Granular Casts.

Fibrinous casts are simply blood-stained hyaline molds, and are of common occurrence in hemorrhagic nephritis. Irregular yellow-brown pseudocasts of wavy fibrin may be found in many forms of hematuria. Cast-like conglomerations of pus-cells are significant of renal abscess or pyonephrosis, but one should not mistake for these groups the larger clumps due to pyelitis, prostatitis, or leucorrhea. Pus-casts from the seminal ducts sometimes accompany seminal vesiculitis.

Granular casts denote most often subacute or chronic parenchymatous nephritis, especially when accompanied by considerable albumin and dropsy. The coarser the granulations,

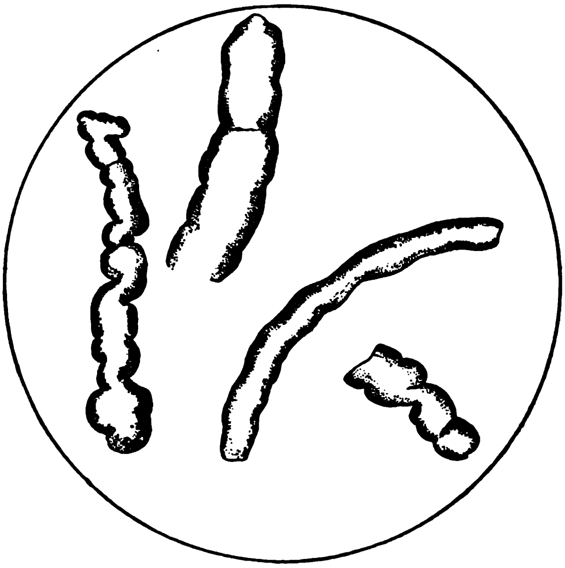


Fig. 91.—Waxy Casts.

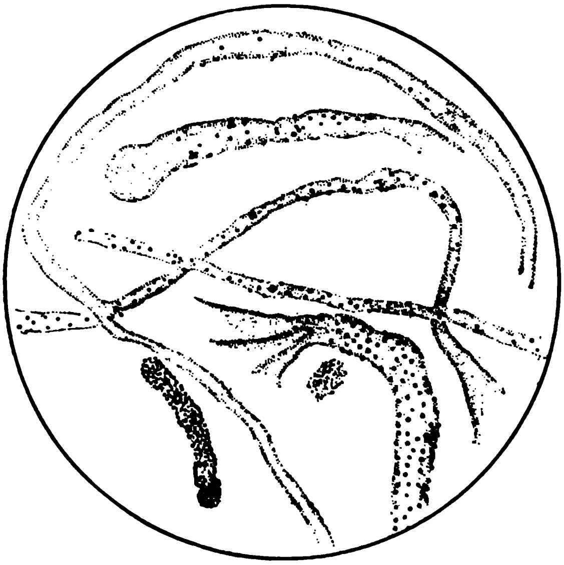


Fig. 92.—False Casts.

the more acute is the disease; the finer, the more chronic. These finely granulo-hyaline casts are often observed in the same conditions as simple hyaline casts: for instance, in uric-acidemia and in cyanotic induration of the kidneys. Coarsely granular casts have been observed in renal cysts. Brownish, blood-stained, granular casts are sometimes encountered, along with blood-casts, in scurvy, hemophilia, and other blood dyscrasias and in hemorrhagic nephritis.

Short stumps of casts, both hyaline and granular, are found in the urine during and often preceding diabetic coma. During the first week of life hyaline and granular casts have no special significance.

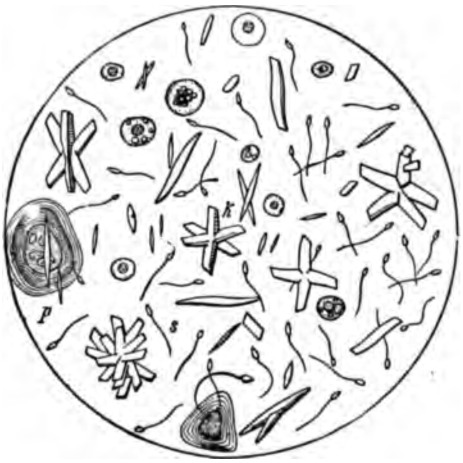


Fig. 93.—Spermatorrhea and Prostatorrhea. × 350. (*Lenhartz.*) *s*, Spermatozoa. *k*, Böttcher's crystals. *p*, Prostatic corpuscles. (Latter after *Bizzozero.*)

Fatty casts, or oil casts, are formed secondarily from granular and epithelial casts, and indicate nearly always a chronic degenerative process. The fat-globules imbedded in these casts are very readily recognized by their glistening, highly refractive appearance. Fatty cylinders are most abundant in the large white kidney of very chronic nephritis. Irregular, cast-like conglomerations of fat-drops, accompanied at times by fatty acid needles (fatty acids and soaps), are sometimes met with in renal abscess, fracture of the long bones, and in poisoning by P, As, Sb, and iodoform.

Waxy or amyloid casts appear as very highly refractive, colorless, or slightly yellow, often cloudy, wavy, and fluted cylinders, usually of large diameter. They are quite brittle; hence often much broken and irregular. They are attacked hardly at all by acetic acid, which is a further distinction from the hyaline cylinders. Some of them, when retained for a long time in the tubules, give the amyloid reaction: a mahogany color with a dilute solution of iodopotassic iodid, turning to a dirty violet on addition of dilute H_2SO_4. Waxy fragments may be found in subacute and chronic parenchymatous nephritis and in renal amyloidosis, which last is usually accompanied by amyloid liver and spleen. They indicate that death is not far away.

Bacterial casts in freshly passed urine are suggestive of interstitial suppurative nephritis, septic embolism, or an ascending pyelonephritis ("surgical kidney"). Similar groups of micrococci (zoöglea) deposited on mucous threads are apt to occur in any urine that has stood for some hours, particularly in warm weather. Bacterial casts resemble somewhat pale, granular casts, and are very resistant even to strong chemic reagents. The bacteria about the border of the cast are in constant motion.

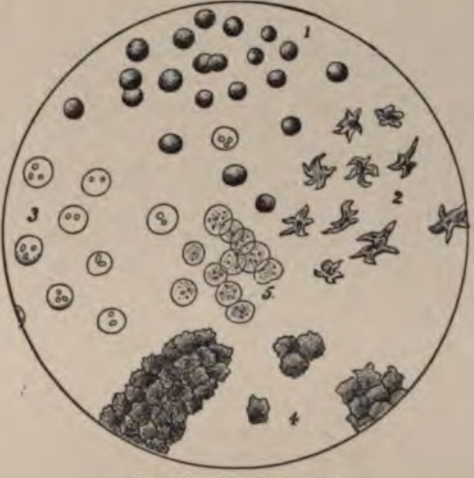


Fig. 94.—Pus-corpuscles.

Deposits of urates on mucin bands and hyaline cylinders give rise to yellowish, pink, or red-brown cast-like formations ("catarrhal casts"), which have at times been mistaken for granular casts. These conglomerations may consist of amorphous urates or of calcium oxalate or the crystalline urates of sodium or ammonium, or rarely of cystin. They are readily distinguished from granular casts by their solubility in warm water or in alkalies. Uratic pseudocasts are of frequent occurrence in the concentrated urine of lithemic persons, especially infants (pseudocasts of $Ca_2H_2\ (PO_4)_2$ in newborn) and children. Similar concretions may be observed occasionally in any cold, dense, acid urine, with "brick-dust" deposit of acid urates.

Prostatic plugs of large caliber, sometimes colored yellow, and usually with imbedded spermatozoa, are found in the urine during mild and chronic inflammations in the region of the prostate. Small, short, narrow pseudocasts, tapering at both ends, come from the prostate in prostatorrhea. Large, broad pseudocasts, from the small canals of the testicle, have been noted in spermatorrhea.

From the above brief *résumé* it will be noted: (1) that tube-casts have general as well as local significance; (2) that no one type is in itself pathognomonic of a single definite lesion; (3) that the various types are pathologically and clinically progressive, changing with the stages of the underlying disease, according to its particular nature.

CELLS.

A few leucocytes are present in every urine. They are about twice the size of red blood-cells. Any considerable number indicate irritation, inflammation, or ulceration (with red blood-cells) of some part of the genitourinary tract. Pus-cells are readily distinguished by their granular appearance and by their nuclei (rarely mononuclear), which, if not apparent, can be brought out by treating with a drop of dilute acetic acid. The nuclei are often coalesced in horseshoe form (chronic inflammation), made evident by staining. Von Jaksch states that leucocytes are stained a deep mahogany-brown (glycogen reaction) by iodopotassic iodid solution, while small round cells are stained light yellow. In the presence of alkalies the nuclei of pus-corpuscles are broken down into a glairy, mucus-like mass, in which only the nuclei may be visible. Albumin is always present in the supernatant liquid when there is a macroscopic deposit of pus. The purulent urine of chronic cystitis is generally ammoniacal, except in tubercular and calculous cases. A sudden gush of greenish pus is likely to have come from a ruptured abscess or pyonephrosis.

In gonorrheal urethritis the pus-cells are held together in threads and bands by mucin, and are sometimes attended by spermatozoa. The appearance of mononuclear cells is the first sign of the extension of the catarrhal, epithelial process to the submucosa. The pus is often clumped and mixed with small round cells in chronic pyelitis. "Ragged, crenated, ameboid, distorted" leucocytes are apt to be from the renal pelvis; those uniformly round are probably from the bladder.

According to Senator, the leucocytes found in Bright's disease or renal tuberculosis are mononuclear, while those present in inflammation of the urinary tract from the pelvis downward are polynuclear.

Mucus corpuscles vary in size from a pus-cell to several times larger. They are pale, rather irregular, finely granular, and non-nucleated. They are always accompanied by mucin bands. An excess of mucus is observed in irritative conditions below the kidneys. The nebecula in these cases is greatly increased, and the urine becomes viscid, slimy, and ropy.

Red blood-corpuscles, if present, on centrifugation are thrown down in a dense, reddish layer, of a much deeper shade usually than the urates. The supernatant liquid shows a trace or more of albumin. Under the microscope the colored blood-cells are ordinarly easily recognized by their biconcave discoid form. The difference in focus between the central circle and the outer ring is shown by the separate focus of each, one appearing dark when the other is light. Normal blood-corpuscles are yellow and are not arranged in *rouleaux* as in blood from other sources. In dense urine they become crenated. Abnormal blood-cells, such as have been in the urine for some time (blood- rings or shadows, "washed-out" blood-corpuscles), are swollen, biconvex, and devoid of color and about two-thirds the size of normal cells; a few of these are commonly to be seen throughout the intervals of renal colic due to stone. Blood-casts are certain evidence of a renal origin. Red cells well preserved are most likely from the bladder (except vesic tumors).

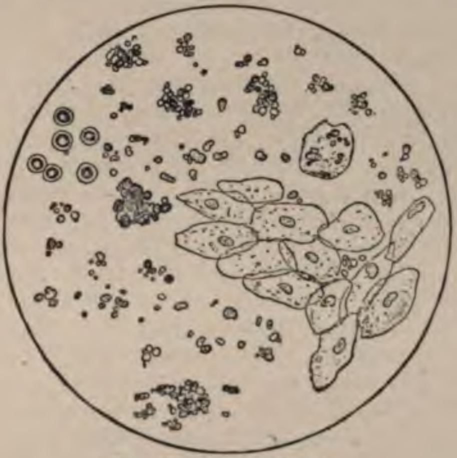


Fig. 95.—Hemoglobinuria.

Distended forms are most common with vesic hemorrhage. Blood-pigment particles are usually amorphous, rarely crystalline (hematoidin). They are distinguished from the much rarer bilirubin by their insolubility in KOH. Urine containing much blood can be clarified for finding other formed elements by repeated washing and stirring with tepid water containing a little acetic acid.

Epithelial cells from the genitourinary tract differ in size and shape according to their anatomic source, the layer from which they were derived, and the reaction and density of the urine. A lining of stratified epithelium—first layer flat, or squamous; middle layer cuboidal, or round; deep layer columnar, or cylindric—exists in the renal pelves, ureters, bladder, urethra, vagina, and cervix of the uterus; a simple epithelial lining obtains in the uriniferous tubules, the prostate, ejaculatory ducts, Bartholinian gland, and uterine mucosa.

The size of epithelia from the same site varies at different times; thus, in light, slightly acid or alkaline urines the cells swell up, while in dense, acid urines they shrink. The leucocytes, which are practically always to be found, also shrink or swell in the same proportion, and are convenient as a standard for the measurement of epithelia with a view to determine the origin of the latter. Epithelia are distinguished from leucocytes by their larger size and the presence of a single nucleus usually distinct without the aid of reagents. They may be stained with blood or bile.

The "round", polygonal, or cuboidal renal cells are from two-thirds the size to about a third larger than the leucocytes in the same specimen. They are highly granular, with a relatively large nucleus, and are much distorted in degenerative processes. The round cells from the prostate and the caudate and spindle cells from the ureters are twice the size of pus-corpuscles. Prostatic cells are often found adherent to shreds of mucin ("prostatic casts"), and are usually accompanied by leucocytes, and frequently by spermatozoa. The small, brown, caudate cells from the renal pelvis are a little larger than those from the ureters, and are commonly arranged in groups like the shingles on a roof; their tails are often curved and sometimes bifurcated. These cells are always accompanied by more or less blood and often by crystals. The small round cells (not much larger than leucocytes, and with bright nucleus) from the deeper layer of the pelvis are often arranged in clumps and are always accompanied by pus. Epithelia from the calices are rarely found. They are somewhat larger than the tubule-cells and generally overlap one another, forming clumps. They have a large, prominent nucleus and are seen in acute pyelitis.

Epithelia from the neck of the bladder are three to five times the size of a leucocyte. They are usually thick and round or oval, with a small, prominent nucleus. From the fundus the cells are still larger, and if from the superficial layer are flat, thin, and polygonal, and joined by their edges; thin and circular from near the ureteral orifices.

Male urethral cells are one and one-half to two times as large as leucocytes, and are very irregular. The dense, squamous variety obtains in the prostatic portion of the canal; the columnar, forward. They are commonly clumped with pus in threads of mucus. The round or pyriform prostatic cells may be accompanied by prostatic casts, which are simply long shreds of mucin entangling phosphates. Seminal cells are readily distinguished by the presence of spermatozoa both free and in the cell. These cells are of medium size, round in form, and highly granular, with an ill-defined nucleus.

The largest cells encountered in urine are those from the vagina. They are squamous, warped, and arranged overlapping in sheets, only slightly granular, contain many bacteria, and are commonly accompanied by pus-cells. They are polygonal and thinner and more granular than vesic epithelia. They are due to leucorrhea, menstruation, or masturbation. Vulval cells and cells from the glans penis are apt to take on the character of dried, jagged, epidermal scales without a nucleus and often studded with fat and dirt: the so-called smegma.

Small, ciliated epithelia may come from the body of the uterus (prismatic, with ordinary vaginal cells during menstruation) or the ejaculatory ducts. The cells from the female urethra are large and round or oval, quite similar to those from the neck of the bladder. Those from the Bartholinian glands are exactly the counterpart of the prostatic cells. Epithelia from the neck of the uterus are flat, cuboidal, and columnar, and quite irregular; they are somewhat smaller than those from the vagina. Decidual cells are large, round, polygonal, or spindle-shaped, with large nuclei and nucleoli.

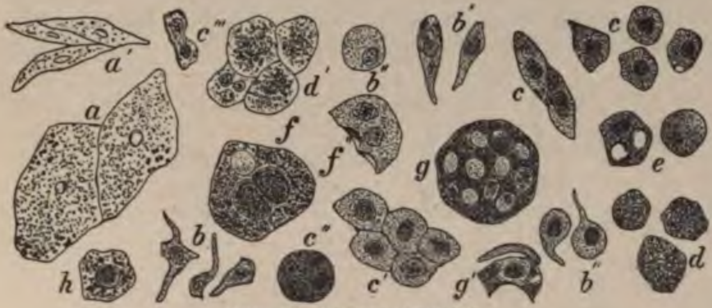


Fig. 96.—Urinary Epithelia.

While a small number of epithelia (vesic, especially) may be said to represent the normal "wear and tear" of the mucous membrane, large numbers indicate irritation or inflammation.

Fatty degeneration of cells, except vaginal, is an indication of a chronic inflammatory condition of the part involved. If the fat-drops have been washed out, vacuoles are left. Multiple nuclei are generally evidence of adjacent inflammation exerting pressure, as in the case of a perirenal or perivesic abscess. Fatty renal cells are noted, not only in subacute and chronic diffuse nephritis, but also in the fatty stage of acute nephritis and severe renal congestion, as in cholera and other acute infections. These fatty renal cells are not to be mistaken for the compound granule-cells, which are larger, round epithelia that have undergone complete fatty degeneration, and show no nucleus, but sometimes fatty needles. They have been observed in nephritis, chronic pyelitis, cystitis, prostatitis, and urethritis; also in ulcerations and in the contents of a ruptured abscess or cyst, as well as in vaginal secretions. They are of diagnostic importance only in connection with casts.

Chyle or fat in the urine is recognized microscopically as highly refracting globules with dark, broad borders, dissolving more or less on the addition of ether.

Fat is seen in large drops sometimes in the large white kidney; also frequently in chronic prostatitis, and occasionally in severe acute fevers and in oxaluria. Fatty granules, spherules, and epithelia occur, along with frequent hemorrhages, in urinary cancer.

All urine containing any appreciable amount of blood always contains wavy bands of fibrin with refractive margins. Connective-tissue shreds are made up of bundles of wavy, highly refractive fibers and fibrillæ. They are found in ulceration, suppuration, hemorrhage, trauma, tumors, prostatic hypertrophy and inflammation, renal cirrhosis, renal atrophy, and all intense inflammatory processes. Spermatozoa are found in the urine after sexual intercourse or emissions, and almost constantly in the very rare condition of true spermatorrhea; also frequently in chronic prostatitis, and occasionally in severe acute fevers and in oxaluria. Spermatozoa are about one six-hundredth of an inch long, and consist of a flattened, oval head and a long, tapering tail. The motion of these bodies soon ceases in the urine. In spermatocystitis the head often becomes granular, like a pus-corpuscle. Spermatozoa are usually accompanied by granular cells, with and without nuclei, and rarely by spermatic crystals and lecithin bodies.

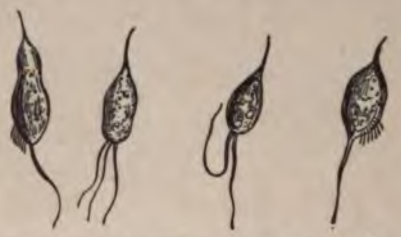


Fig. 97.—Trichomonas Vaginalis. (*Todd.*)

Amyloid corpuscles from the prostate are pale, irregular, oval, or angular concentric bodies having a high refraction and often a central nucleus. They are colloid in structure, and are increased in numbers in prostatic hypertrophy. They are colored red by methyl-violet (starch, blue). They may form the basis of prostatic concretions.

Fragments of urinary tumors are occasionally found, particularly papillomatous shreds and sarcoma-corpuscles. These are compact, granular bodies a trifle smaller than pus-cells, and are nearly always accompanied by large shreds of connective tissue. Cancer-cells and the pigmented cells of melanoma are rarely seen. Epithelial cells with prominent nuclei and of varied shapes are suggestive of a new growth. Villi of growths covered with multilamellated epithelia may sometimes be obtained by moving a catheter about in the bladder.

The most common parasite found in the urine is the trichomonas vaginalis: a harmless habitant of the vagina in cases of leucorrhea. In the bladder it may give rise to dysuria and hematuria. It has an oval head, often nucleated, with a large tail or several flagella. It is much larger than spermatozoa. The cercomonas is similarly of no significance. Other urinary parasites are the filaria sanguinis hominis (embryos in urine; causes chyluria), distoma hematobium, echinococci (hooklets, motile scolices, or fragments of cystic membrane), ascarides, oxyuris vermicularis (little girls), and eustrongylus.

BACTERIA.

Germs seem to have the power of spontaneous entrance to the bladder in paralysis of this organ. Bacteriuria is, in general, a sign of catarrh of some part of the urinary tract, particularly of the renal pelvis. Sarcinæ in the bladder may produce obscure vesic symptoms.

The flora of the urethra, according to Warren, includes the bacterium coli commune, coccobacillus liquefaciens urethræ, bacillus urethræ non-liquefaciens, leptothrix urethræ, diplococcus candidus urethræ, pseudogonococcus, gonococcus of Neisser, staphylococcus ureæ liquefaciens, streptococcus pyogenes, streptococcus liquefaciens urethræ, sarcina urethræ, smegma bacillus, tubercle bacillus, bacillus typhosus, staphylococci pyogenes aureus and albus, and streptobacillus anthracoides.

Of the vesic flora, the bacterium coli commune is the most common cause of acid cystitis, gaining access to the urine in case of obstinate constipation or other bowel trouble. The urobacillus liquefaciens septicus (proteus vulgaris Hauser) is pyogenic and decomposes urea, setting up ammoniacal cystitis and pyelonephritis. The diplococcus and the staphylococcus ureæ liquefaciens (Melchior) also rapidly decompose urea; the streptobacillus anthracoides slowly. The staphylococci aureus and albus are common pus-producers and also decompose urea. The bacillus lactis aërogenes is responsible for most cases of pneumaturia, in which bubbles of gas (H) are passed with the urine. The pseudodiphtheria bacillus is a common species. A long bacillus is often found in the urine of cystitis.

DIFFERENTIATION OF THE NEPHRITIDES.

NAME.	SYMPTOMS.	PHYSIC SIGNS.	THE URINE.		
			PHYSIC.	CHEMIC.	MICROSCOPIC.
Acute diffuse.	Dull aching and tenderness on deep pressure in small of back; uremic symptoms (headache, twitching, nausea, vomiting, dyspnea, convulsions, coma).	Pallor and puffy eyelids or anasarca; tense pulse, fever.	Diminished or suppressed; dark and sooty or porter-colored; 1.020 to 1.030.	Marked absolute reduction of urea and inorganic salts; much albumin, sometimes albumoses; reaction acid.	Large numbers of mixed casts (blood, leucocyte, epithelial, broad hyaline, coarse granular); many renal epithelial cells and red and white blood-corpuscles.
Chronic parenchymatous.	Marked debility and mild chronic uremia (headache, insomnia, vomiting, diarrhea, nocturnal dyspnea, visual disorders).	Progressive general edema, beginning in eyelids; early marked pallor; cardiac hypertrophy in secondary shrunken kidney.	Usually diminished; may be suppressed in exacerbations; pale and hazy; 1.010 to 1.020.	Same as above, but with even more albumin.	Heavy sediment of degenerated casts,—fatty, broad hyaline and dark granular,—fat-granule, renal cells, fat drops and granular *débris*; red blood-cells and blood-casts in hemorrhagic form.
Chronic interstitial.	Frequent micturition—must rise at night; recurrent epistaxis; nocturnal dyspnea, headache, post-cervical neuralgia, visual disorders, itching, sweating, vomiting, diarrhea, cramps in muscles, tinnitus, vertigo, drowsiness, convulsions, coma.	Progressive loss of flesh and strength; progressive hypertrophy of the left ventricle — second aortic sound loud and sharp; pulse hard, full, tense, and tortuous; dry, harsh skin; often systolic murmurs in late stage.	Great progressive increase, diminishing with failing compensation; pale and transparent (may be occasionally bloody); 1.008 to 1.015, rising again toward end. Night urine more than day.	Frankly acid; urea only one-half or one-fourth of normal daily quantity in advanced cases; phosphates also reduced; albumin slight and intermittent, increasing in later stage; increase of indoxyl.	Faint sediment, containing but few narrow hyaline and faintly granular and waxy casts; a few degenerated renal cells; many crystals of uric acid and calcium oxalate common in early stage; blood in all stages in disease due to lead or arsenic.
Waxy, or amyloid.	More frequent micturition; dyspepsia, diarrhea, debility; syphilis, tuberculosis.	Sallow cachexia and wasting; slight dropsy; feeble, thready pulse; enlarged liver and spleen.	Pale and transparent; quantity usually above normal, and sp. gr. below.	Acid reaction; slight decrease of urea and phosphates; large, but variable, amount of albumin and globulin.	Slight sediment, containing a few renal cells and leucocytes, and a moderate number of broad, hyaline, and yellow, waxy casts.
Suppurative.	Constant dull, throbbing pain along spine; severe rigor, high fever, sweating, and typhoid-like state.	Kidney enlarged, tender, and often fluctuating; ureteral catheterization or segregation of urine distinguishes affected side.	Scant, cloudy, offensive, and may be bloody; 1.006 to 1.016.	Acid unless disease has extended from below, decomposes quickly; urea much diminished; albumin in excess of pus and blood.	Heavy sediment of pus and bacteria, blood, degenerated epithelia, connective tissue, and *débris*; casts usually present—sometimes bacterial.

In urine that is undergoing putrefactive changes micrococci ureæ are most constant. These appear under the microscope as trembling points, isolated or collected in strings. The bacterium termo, another common putrefactive micro-organism, appears as comparatively large, oblong cells, often joined in pairs or longer chains. In stale urine we often see zoöglea groups of cocci:. that is, masses of cocci enveloped in a colorless, gelatinous capsule. The bacillus subtilis, or hay bacillus, is a large bacillus frequently found in decomposed urine, and various actively motile vibriones are likely to gain access from the air or from unclean vessels. Leptothrix threads are sometimes seen, and in large numbers may give rise to myotic cystitis; in such cases they may be seen in the urine as whitish pellicles with the naked eye. Yeast-cells, or saccharomycetæ, are found in acid urine (sometimes from floating dust of air), particularly in cases of diabetes mellitus, along with bacteria and molds, on standing, and are often arranged in arborescent groups.

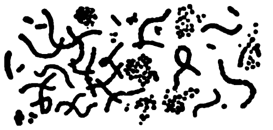


Fig. 98.—Micrococcus Ureæ.

They are distinguished from colorless blood-cells by their oval shape, irregular size, budding, and nuclei. Oïdium lactis is a common mold-fungus of the acid urine, and consists of jointed stems (mycelia) and vacuolated spores (conidia). The penicilium glaucum and aspergilli are much less frequent in urine. The hypha of the latter fungi ends in a spheric or club-shaped vesicle; the hyphæ of the former divide and subdivide into thread-like basidia and streigmata. Leptothrix threads and spores and those of actinomyces and soor (thrush fungus from vagina) are rarely found in the urine.

Of pathogenic urinary bacteria the tubercle bacillus is most important. It is pyogenic and gives rise to acid cystitis and pyelitis. Tuberculous lesions may be either primary or secondary. The smegma bacillus resembles the tubercle bacillus in form and in reaction to the common stains, but is usually single and without pyuria; it is usually excluded by treating with alcohol, which decolorizes the smegma, but not the tubercle bacillus. To detect tubercle bacilli in the urine centrifugate, wash sediment by decantation with distilled water, and centrifugate again; fix sediment by heating gently over a copper or iron plate; stain with carbol-fuchsin, then decolorize in 20-per-cent. HNO_3 and again in 70-per-cent. alcohol (for at least ten minutes), and counterstain with aqueous solution of methylene-blue. Tubercle bacilli are often difficult to find when present in the urine, and in case of doubt some of the urine and sediment should be injected into guinea-pigs. The bacilli are most likely to be found in the residual urine drawn from the bladder by catheterization.

The gonococcus is a frequent habitant of the genitourinary tract, and is the commonest cause of suppuration in both sexes. Gonorrhea is usually a mixed infection. Coplin's method of staining gonococci is as follows. Stain with saturated alcoholic solution of methylene-blue for five to fifteen minutes, wash in water, and then stain with saturated alcoholic solution of eosin for the same length of time. Wash in water, dry, and mount. The nucleus of the pus-corpuscle and the diplococci contained in the cells are stained blue; the protoplasm of the cells, pink. Diplococcus urethræ resembles the gonococcus in all respects, except that it is not found in the pus-corpuscles.

The streptococcus pyogenes is the commonest germ of puerperal fever. The bacillus typhosus is present in at least 25 per cent. of cases of typhoid fever during convalescence. The diplobacillus of Friedlander is occasionally present in the urine, particularly during an attack of pneumonia. Other unusual pathogenic urinary bacteria are the streptococcus erysipelatis, spirillum of relapsing fever, bacillus of glanders, anthrax bacillus, sarcinæ, and bacillus of ulcerative endocarditis.

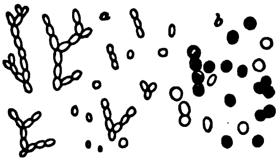


Fig. 99.—Yeast Fungus. (After *Harley*.) (*Lenhartz*.)

THE URINE IN VARIOUS GENITOURINARY DISEASES.

Renal Arteriosclerosis.—Low sp. gr.; often mere traces albumin; diminished urea; withered epithelial cells, narrow hyaline and granular casts and sometimes blood-cells; senile atrophy.

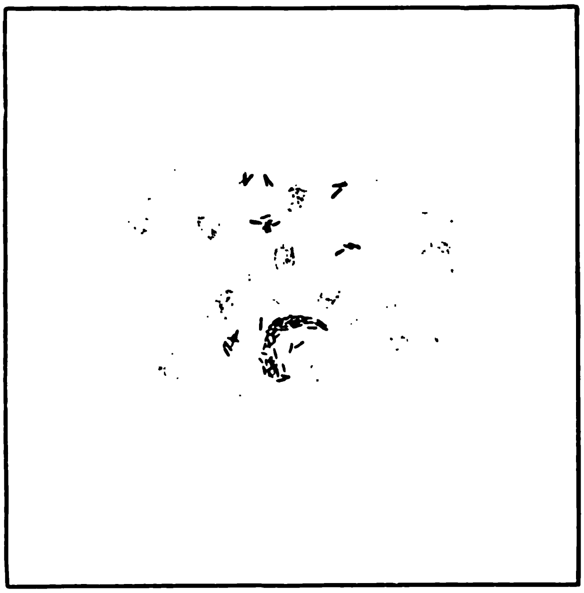
Passive Renal Hyperemia.—Differs from active by diminution of solids and by absence or scanty numbers of blood and epithelial cells.

Renal Calculus.—Urine somewhat diminished, smoky or porter-colored, sharply acid (may be alkaline later); small amount albumin; red blood-cells (1 to 20 swollen phantom corpuscles in each field in nearly every specimen in intervals of attacks); few leucocytes (many in tuberculous disease) until pyelitis supervenes.

Acute Pyelitis.—High color (sometimes red); diminished quantity; acid reaction; solids about normal; slight amount albumin, blood and pus (clumped); crystals and caudate cells; shreds of mucin, fragments of connective tissue; casts if tubules involved.

Chronic Pyelitis.—Urine abundant, pale yellow, cloudy, 1.008 to 1.010; flocculent purulent sediment; often hemorrhage with cylindric clots—sudden changes in appearance of urine from closure of one

PLATE XIII.



TUBERCLE BACILLI IN URINARY SEDIMENT.

(After v. Jaksch.)

PLATE XIV.

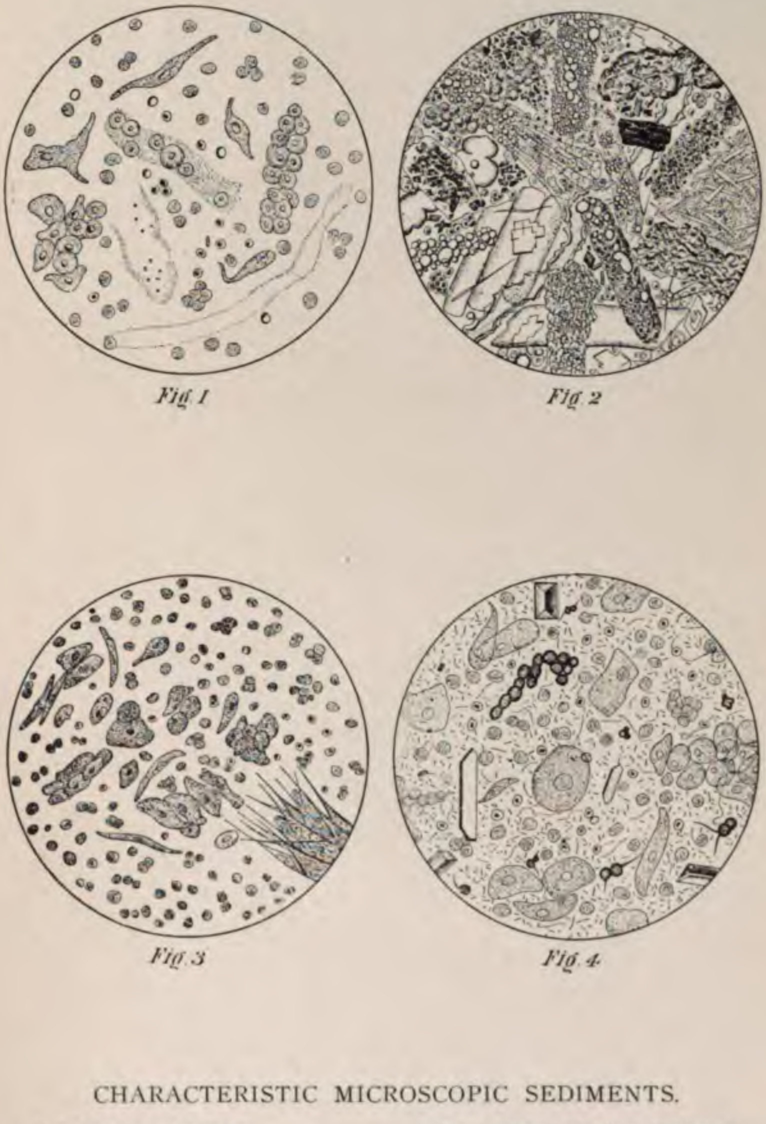


Fig. 1 *Fig. 2*

Fig. 3 *Fig. 4*

CHARACTERISTIC MICROSCOPIC SEDIMENTS.

Fig. 1. Acute Nephritis. **Fig. 2. Chronic Diffuse Nephritis.**
Fig. 3. Pyelitis. **Fig. 4 Cystitis.**

ureter; albumin more by volume than sediment; papillary plugs ("pus casts"); hyaline and granular casts if coexistent renal irritation; usually bacteria.

Hydronephrosis.—Periods of sudden excess; low sp. gr.; albumin in slight amount, increasing on escape of confined urine; abundance of angular and spindle-shaped epithelia, few pus-cells, sometimes red blood-corpuscles.

Movable and Floating Kidney.—Urine often scanty or temporarily suppressed; usually small quantity of albumin; spindle-shaped epithelia and at times blood and pus-cells.

Cystitis.—Albumin less by volume than sediment—albumin absent in irritable bladder. Mucous catarrhal: faintly acid, non-albuminous; scanty sediment of epithelia and leucocytes. Purulent catarrhal: sediment finely flocculent in acid, greenish and slimy in alkaline; slight albuminuria; large number of bacteria and triple phosphate crystals. Tuberculous: purulent urine, distinctly acid; tubercle bacilli difficult to find. Calculous: urine usually alkaline; last portion may contain bright blood, especially after exercise; crystals, vesic epithelia and mucopus.

Prostatitis.—Urine pale, turbid, diminished, acid, low sp. gr.; slight trace albumin (also mucin); pus discrete or clumped in mucin shreds; long narrow and small round epithelial cells, often side by side and stained at base with blood-pigment; blood-corpuscles, amyloid bodies, granular seminal bodies (size of pus-cell), spermatozoa and prostatic plugs. Examine first portion of urine.

Seminal Vesiculitis.—First portion of urine after milking vesicles contains pus, mucous globules, phosphates and spermatozoa; sometimes blood, particularly if tuberculous.

Urethritis.—Short, thick tack- or comma-shaped shreds from urethral crypts and follicles; albumin from pus (in excess of pus) in acute stage of posterior form. Sediment mucoid or purulent in simple acute inflammation. Acute gonorrhea: mucoid at first; in two or three days yellowish-green or dirty brownish-red, and again mucoid; leucocytes containing gonococci; squamous, polygonal or caudate oval epithelia. Chronic gonorrhea: translucent mucoid or opaque yellow threads or shreds in urine; morning drop; cylindric and goblet cells, club-shaped and sickle-form epithelia, with small nuclei, sometimes in clumps or bands.

THE URINE IN THE DIAGNOSIS OF NON-URINARY DISEASES.

We judge most certainly the condition of a living organism by comparing its intake and its output. The urine is the chief index of metabolism in the human body, and its qualitative and quantitative examination furnishes evidence of the greatest practical value. In chronic non-urinary diseases in general the urine is diminished, usually pale and faintly acid or alkaline, and the normal salts are decreased. There is usually a trace of albumin, and sometimes a few casts.

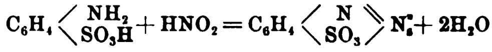
SPECIFIC INFECTIONS.

During the febrile stage of all fevers the urine is diminished in quantity and highly acid. The sp. gr. shows a relative increase, owing to the absolute excess of urea depending on augmented tissue-waste. Uric acid is increased proportionately even more than urea, and uratic deposits are common. In cholera and in fatal cases of other diseases urea is greatly diminished during the last day or so of life. The excretion of chlorids and phosphates (except in spotted fever) is diminished until the beginning of convalescence, and is most marked when there is a serous effusion.

Pigmentation is deepened because of hemolytic changes, and bile-pigment is not infrequently present, particularly in smallpox. Hemoglobinuria is indicative of decided destruction of red blood-corpuscles; it accompanies severe infections, and is a valuable premonitory sign of scarlatinal hematuria and nephritis. Albuminuria is observed at some time in the majority of cases of fevers generally, but is usually slight in quantity unless nephritis (common in erysipelas, diphtheria, and scarlet fever) complicates. Albumosuria is occasionally noted, particularly in pyemia, typhoid, pneumonia, and cerebrospinal meningitis, and a trace of glucose is not uncommon. Hyaline casts are frequent, even without supervening nephritis—in the event of which we find also epithelial, red blood-, leucocyte, and granular casts. Chronic pyelitis is a more frequent sequel of infectious diseases than is chronic nephritis. Urinary pigments are much increased in pneumonia, and indican in cholera.

The special color-test of typhoid fever known as Ehrlich's diazo reaction has been ranked by good authority as of equal value with Widal's agglutination test. It occurs a day or two earlier (fifth to ninth day usually) than does the serum-reaction, and serves quantitatively for prognosis, whereas the serum-reaction is said to have no prognostic significance; the diazo reaction may be absent throughout the course of very mild cases of enteric fever. This reaction is of special use in differentiating typhoid from simple enteritis and allied complaints. It is likewise met with in miliary tuberculosis (usually not till the third week), carcinoma, and in severe cases of measles, scarlatina, erysipelas, pneumonia, typhus, septicemia, and pyemia, as also in cases of ordinary phthisis which are rapidly progressing to a fatal termination. In all these instances its occurrence is chiefly an item of prognosis.

The Ehrlich reaction depends upon the red color produced by the action of diazobenzolsulphonic acid, in the presence of excess of NH_4OH, on alloxyproteinic acid in the urine of typhoid and other diseases. Two solutions are required and should be kept in a dark place. The first consists of 10 c.c. HCl with 200 c.c. of a saturated aqueous solution (5 gm. per liter) of sulphanilic acid. The second is a 0.5-per-cent. aqueous solution of sodium nitrite, made as fresh as possible. The reaction between these two solutions may be represented as follows:—



$$C_6H_4\left\langle\begin{matrix}NH_2\\SO_3H\end{matrix}\right. + HNO_2 = C_6H_4\left\langle\begin{matrix}N\\SO_3\end{matrix}\right\rangle N + 2H_2O$$

To apply the test mix 40 parts of the first solution with 1 part of the second (Greene), add an equal volume of urine, shake well, and allow an excess of NH_4OH to run slowly down the side of the tube. If the reaction is positive, the foam will be colored pink and the urine crimson. The color of the foam is the most essential feature, since all febrile urines give an orange color with the test solution. If the mixture is poured into a porcelain dish containing water, a salmon-red color is obtained when the reaction is positive, while a yellow or orange color is negative.

The sudden disappearance of this reaction in typhoid, without improvement in the clinical symptoms, may mean renal involvement or some secondary infection. The diazo reaction may be simulated by the patient's taking salol, antipyrin, phenacetin, salicylic acid, creosote, resorcin, codein, quinin, digitalin, chrysarobin, or naphtalin, and by excess of indican, urochrom, or diacetic acid. It is prevented by drugs containing tannin or iodin.

HEMIC AND CIRCULATORY DISORDERS.

The relative value of the *vis a tergo* is the all-important factor in the causation of the urinary changes of circulatory origin. When cardiac hypertrophy exists, and compensation is maintained, there is absolute increase of both the water and the solids of the urine. Failing compensation is marked and measured by decrease of the solid ingredients and by the presence of albumin and hyaline casts, both of which may be made to disappear for a time under the administration of digitalis and other cardiac tonics. Much the same picture as to the urine presents itself in the secondary cardiac dilation of valvular disease, and in arteriosclerosis and the various myocardial degenerations. Glucose and lactic acid are sometimes present.

Concerning blood-changes proper, hematuria or hemoglobinuria, apparently spontaneous, is of rather common occurrence in purpura hemorrhagica, scurvy, and hemophilia. A pale urine, deficient in normal solids, is a feature of chlorosis and anemias. In progressive pernicious anemia indicanuria is a prominent sign. A small amount of albumin may be encountered in any of the blood dyscrasias as well as in degenerative lesions of the ductless glands. Remembering the nucleinic origin of uric acid, a great excess of this ingredient in the urine of leukemia is not surprising. Ulcerative endocarditis and hidden pyemic foci may discover themselves first by renal infarcts, with sudden pronounced albuminuria and blood- and pus- casts. Fatty cells and casts are not uncommon in leukemia.

RESPIRATORY DISEASES.

The chlorids show a reduction in all dyspneic conditions, particularly in pneumonia and capillary bronchitis. The excessive excretion of chlorids following retention is a more definite sign of resolution than even the fall of temperature by crisis or lysis. Urea and sulphates are markedly increased except in grave cases, and the urates are enormously augmented. Albuminuria is present in nearly one-half of all cases of pneumonia, and these yield a mortality three times as great as in non-albuminuric patients. Albumosuria or peptonuria is a distinctive feature of the absorption stage in pneumonia and pleurisy with exudation. The urine of phthisis is very variable. It is usually increased in quantity till near the fatal end. Albuminuria is the rule, but the quantity is slight except in subacute glomerular nephritis or tuberculous ulcers in kidney or bladder, or in amyloid renal lesions, which are comparatively rare. The urine of emphysema is also likely to contain albumin, owing to circulatory obstruction.

GASTROINTESTINAL DISEASES.

In organic disease of the stomach and intestines, and in acute peritonitis, the urine, as a rule, is diminished in quantity, the diminution amounting to suppression at times in the various forms of cholera, in appendicitis, and in acute obstruction. The reaction is frequently neutral or alkaline, with resulting precipitation of earthy phosphates, or "phosphaturia." The normal digestive curve of acidity is always deepened in gastrosuccorrhea, but is absent in atrophic gastritis and cancer of the stomach. The chlorids are deficient in carcinoma ventriculi (with excess of N) and in dilation (N diminished) with gastrosuccorrhea; also in acute general peritonitis. Intestinal indigestion is characterized by deposits of urates and oxalates. A trace of albumin, attributable to autointoxication, is not seldom to be found, and albumosuria is often present in ulcerative conditions. Next to pus, an excess of "indican" is the most familiar feature of pathologic urines. This indicanuria signifies, as a rule, albuminous putrefaction in the alimentary tract, and the indications for laxatives and intestinal antiseptics are plain. In acute or chronic intestinal obstruction the excess of indican is apt to be enormous, and it is likewise marked in general peritonitis. Hydrothionuria naturally gives rise to a suspicion of fecal fistula, but the same sewer-gas odor may be developed by certain microorganisms introduced *per vias naturales.*

HEPATIC AND PANCREATIC LESIONS.

In all liver lesions the urine is highly acid and deeply colored. Bile-pigment is commonly present in considerable amount. Urea is more or less diminished, being nearly absent and replaced by ammonia and leucin and tyrosin in acute yellow atrophy. Uric acid is increased, while the chlorids are diminished in direct proportion with ascites. Albumin is noted in cases secondary to cardiac lesions and in syphilitic, tubercular, and amyloid livers. Albumin and casts often accompany gall-bladder infections and obstructions of the common duct.

A trace of sugar is not infrequent in liver disorders generally. In obstructive jaundice choluria is evident both before and after the appearance of icterus in the skin. The conjugate sulphates are much increased in obstructive jaundice; the total sulphates diminished in the non-obstructive form. The choluria of cholelithiasis is of distinct service in differentiating hepatic from renal colic and other abdominal pain. Leucin and tyrosin are occasionally noted in various hepatic affections as well as in defective intestinal digestion, but they are much more abundant in acute yellow atrophy; the casts and cells show fatty degeneration of the kidneys, and are usually stained yellow.

In hepatic insufficiency the urine contains albumin and hyaline and granular casts. In the advanced stage glycosuria is constant, with deficient urea, indicanuria, and urobilinuria. Urinary toxicity is diminished, and the elimination of methylene-blue is retarded. A striking character of the later stages of hepatic cirrhosis is the coincidence of a urine dark in color and light in weight: always a sign of grave import.

Chronic pancreatitis is marked by polyuria, glycosuria, and lipuria. There may be albumin or glucose in the urine of patients with pancreatic cysts. Lipuria is also observed in cancer of the pancreas, and diabetes mellitus may supervene. The "pancreatic reaction" of Cammidge differs from Williamson's test for glycosuria in a preliminary treatment with acid, whereby glycerin is changed to a glycerose, and oxalic acid breaks up into formic and carbonic acids. It is suggestive, though not pathognomonic, of disease of the pancreas.

Cammidge-Schroeder Pancreatic Test.—Forty c.c. of the urine, filtered, acid reaction, free from albumin and sugar, are boiled with 2 c.c. of strong hydrochloric acid for ten minutes. After partly cooling, 8.0 gm. of lead carbonate are gradually added. When the reaction is complete, the mixture is chilled, filtered, and 10 c.c. of filtrate diluted to 20 c.c. with distilled water. This solution is precipitated with 2.0 gm. of tribasic lead acetate, filtered, and the excess of lead in solution removed by the addition of 2.0 gm. of sodium sulphate, bringing the mixture to a boil, chilling and filtering to 20 c.c. To this filtrate there is now added a mixture of phenylhydrazin hydrochlorate 0.80 gm., sodium acetate 2.0 gm. and of 50 per cent. glacial acetic acid 1 c.c., and the whole is boiled on a sand bath for ten minutes. The solution is then filtered while hot, and set aside to crystallize. The precipitation of crystals (within twenty-four hours), sometimes only in microscopic quantities, of the characteristic formation of osazones, makes a positive reaction.

The following precautions must be observed: 1. The urine must not contain albumin or sugar, and must be fresh and filtered clear. 2. Positive reactions must be verified by making the phenylhydrazin test for free sugar in the urine, using the same method without previous boiling. Fehling's test is not sufficiently delicate. The sufficiency of removing sugar by previous fermentation has not been proved. 3. Tribasic lead acetate ($Pb(C_2H_3O_2)_2.2PbO$) must be employed.

OSSEOUS, ARTICULAR, AND CONSTITUTIONAL DISEASES.

The urine of acute articular rheumatism is typically pyrexial, with high color, density, and acidity; great excess of urea, sulphates, and urates, and diminished chlorids. Albuminuria is slight and transient. The most marked feature of gouty urine is the nearly constant reduction, from retention, of uric acid and phosphates, with periodic storms of excessive excretion immediately following acute exacerbations. This condition is frequently associated with oxaluria and with chronic interstitial nephritis. In tuberculous joint disease, with abscess-formation, the presence of albumosuria may aid in a correct diagnosis. In gonorrheal arthritis careful examination of the urethral secretions will usually reveal the gonococci. Rachitis and osteomalacia are both distinguished by great excess of earthy phosphates; chronic articular rheumatism and diffuse periostitis, by less marked increase. Fat in the urine is commonly observed after fracture of the long bones, and the return of the earthy phosphates to a normal daily amount, after previous excess, is a certain indication that bony union is complete. Glycosuria often obtains in acromegaly. The urine of lithemia is scanty, sharply acid, high colored, and uratic during the attacks. There is occasionally slight albuminuria, with cylindroids and hyaline casts. The lithemia of infants is manifested by a deposit of red sand on the diapers. Muscular rheumatism is sometimes accompanied by oxaluria. In simple atrophy, or marasmus, the urine is often milky from white urates, fat, and mucus, and albumin or sugar may be present. Albumosuria has been noted particularly in sarcomatosis of the ribs, sternum, and other bones.

NERVOUS DISEASES.

Hysteria is noted for the large amount of watery urine (up to 5000 c.c. in twenty-four hours) which, as a rule, accompanies or follows the seizure; but, on the other hand, there may be suppression lasting for days. Transient polyuria is also observed after epileptic fits, attended at times by a little albumin. In neurasthenia the urine is constantly deficient in normal solids. According to de la Tourette, after hysteric attacks the urine for twenty-four hours shows diminished total solids and total phosphates, and an increased ratio of earthy to alkaline phosphates; whereas, after an epileptic fit the total solids are increased, and the relation of earthy to alkaline phosphates is unchanged. In melancholia the urine is often deficient in quantity, and of high sp. gr. Indoxyl is generally increased in melancholia and acute myelitis.

Oxaluria is apt to show itself clinically by intestinal dyspepsia, lumbar aching, and nervous irritability and depression. Phosphaturia is a frequent accompaniment of nervous debility.

In chorea we find an increase both of urea and of phosphates. Migraine is marked toward the close of the attack by an abundance of uric acid and allied products. Glycosuria is of common occurrence in medullary lesions. Surgical shock, particularly when due to rectal or genitourinary operations, is likely to be joined with urinary suppression or retention. Retention, usually with overflow, is usually present likewise in organic spinal lesions. In meningitis and other high-grade nerve-inflammations the earthy phosphates are greatly in excess. The urine of meningitis tends to paleness, alkalinity, and marked deficiency of chlorids. The three forms of diabetes—insipidus, mellitus, and phosphatic—have already been mentioned.

TOXEMIAS OF PREGNANCY.

In eclampsia (Williams) the total amount of N is greatly diminished, while the ammonia coefficient remains practically normal. In vomiting (acute yellow atrophy), on the contrary, in spite of scanty urine, the amount of total N remains approximately normal, while the ammonia coefficient is wonderfully elevated (from the normal 3 or 5 per cent. to as high as 46 per cent. of total N).

SKIN AFFECTIONS.

Obviously a study of the urine is not often needed in skin diseases proper, so far as concerns diagnosis, yet in seeking the primary cause we shall sometimes get valuable points concerning defective metabolism and autointoxication. Eczema, psoriasis, and a number of other disorders seem, from the urine, to be forms of lithemia. Hematuria is frequent after severe burns and occurs occasionally in Raynaud's disease.

SURGICAL CONDITIONS.

Abdominal tumors may and often do give rise by pressure to albuminuria. The occurrence of melaninuria is nearly pathognomonic of melanotic growths. In perirenal and perivesic inflammation the nuclei of the cells from these sites are often multiple. Internal pus-formation in any part of the body is indicated by albumosuria, the later disappearance of which shows that the abscess has discharged externally or is encapsulated. The resorption of hemorrhagic exudations is revealed by hemoglobinuria. A considerable relative increase of urinary nitrogen over phosphoric oxid is said to be a sign of malignancy.

URINARY CALCULI.

Primary calculi (uric acid, calcium oxalate, calcium carbonate, cystin, xanthin) are formed in unchanged urine. Secondary calculi (ammonium urate, phosphates, urostealith) form in decomposed urine. Compound calculi contain layers of different substances. The nucleus (mucus, epithelium, foreign body) and the outer portion of the stone should be examined separately.

The smaller, irregular concretions are usually from the kidney body or pelvis; the larger ones, from the bladder. Urethral calculi are oblong or cylindric. Prostatic concretions usually have a laminated nucleus of amyloid corpuscles, enclosed within a shell of phosphates. Concretions forming in alkaline urine have a crust of phosphates, chiefly on the body of the stone. Ammonium urate is the chief constituent of calculi in infants; uric acid, in young adults; calcium oxalate or uric acid, in elderly subjects. Spontaneously exfoliated fragments of a tumor are often encrusted, and so obscured.

DIFFERENTIATION OF URINARY CALCULI.

Heat a portion of the powdered concretion on platinum-foil.

I. The powder burns:
  1. Without a flame:
    - Uric acid: murexid test; no NH_3 odor on treating with KHO; over three-fourths of cases; reddish or yellow-brown and tuberculated.
    - Ammonium urate: murexid test; strong odor of NH_3 on treating with KHO (use red litmus-paper in mouth of tube); light gray; infancy.
    - Xanthin: yellow residue on evaporating with HNO_3 turns orange with KHO, red on warming; very rare. Soluble in dilute (1:2) HCl.
  2. With a flame:
    - Cystin: transient, pale-blue flame; sharp odor; powder dissolved in ammonia yields six-sided plates on evaporation.
    - Urostealith: steady yellow flame with odor of resin; fatty and soluble in alcohol or ether; soft, friable, brown or yellow.
    - Fibrin: steady yellow flame with odor of burnt feathers; insoluble in alcohol or ether, soluble in hot KHO; may contain crystals of hematoidin.

II. The powder does not burn. Treat with HCl:
  1. Effervesces = calcium carbonate; small, smooth, spheric, gray or bronze; very rare in humans.
  2. Does not effervesce:
    - Effervesces on heating gently with HCl = calcium oxalate: very hard and brittle—large, dark, rough, "mulberry" calculi, or small, smooth, rounded, dark-gray "hemp-seed" calculi; often in alternating layers with uric acid, and sometimes crusted with phosphates.
    - Odor of NH_3 on treating with KHO = triple and earthy phosphates: soluble in acetic acid (iron phosphate gives residue of yellowish flakes), and fusible; alkaline urine; gray-white and friable.
    - Faint or no odor of NH_3 on treating with KHO = earthy phosphates: chalky, rounded, or irregular; alkaline urine of elderly persons.
    - Insoluble in HCl = silica: very rare, as are also blue indigo concretions.

POISONS.

Corrosive poisoning in general is attended by scantiness or suppression of the urine, and the same is true of arsenic and belladonna in toxic doses. In acute phosphorus poisoning the urine, if not suppressed, is bloody, fatty, and albuminous, and contains brown, granular, and fatty casts and cells, and crystals of leucin and tyrosin. Turpentine, cantharis, and other renal irritants; illuminating gas, arsenious vapors, coal-tar derivatives, and other corpuscle-destroying agents frequently give rise to hematuria or hemoglobinuria. The blackish-green color (developed on standing, due to glycuronate of hydroquinone and pyrocatechin) of the urine and characteristic odor of carbolic acid are highly suggestive of poisoning by this drug, which is not seldom the result of its free and careless topic use. Mineral sulphates are early diminished (little or no reaction with $BaCl_2$), and conjugate sulphates much increased. Suppression of urine is a very dangerous sign in mercurial poisoning.

Test for Pyrocatechin in Carboluria.—Add dilute $FeCl_3$. The green color which appears is changed to violet on adding a little tartaric acid, then ammonia. On acidulating with acetic acid, the green hue reappears.

Indophenol (Paramidophenol) Reaction (Given by Acetanilid, Phenacetin and other Phenetidin Derivatives).—To about 10 c.c. of urine add ¼ its volume of conc. HCl; allow to cool; add ⅙ volume of 5 per cent. phenol and a few drops of $K_2Cr_2O_7$ solution, getting a red color; add ammonia, turning blue.

Chronic mineral poisoning is characterized, as a rule, by scanty urine and deficient urinary solids. Albuminuria is frequent, and chronic interstitial nephritis is a not uncommon sequel. The detection of lead, mercury, arsenic, copper, etc., in the greatly concentrated and oxidized urine furnishes incontrovertible evidence of the *causâ morbi.* This test is most certain when preceded by the administration of potassium iodid for several days.

Test for Arsenic in Urine (Holland).—Evaporate to dryness, add H_2SO_4 containing 1/30 its volume of HNO_3, and heat residue until dense white fumes are given off. Extract charred materials with boiling water, concentrate solution, and introduce into Marsh apparatus.

QUESTIONS ON CLINIC CHEMISTRY.

1. How may a milk have been skimmed and watered and yet show a normal sp. gr.?
2. Explain how the amount of free gas in the ureometer may be greater at first than after standing fifteen or twenty minutes.
3. Write equation for reaction between uric acid and disodic hydric phosphate.
4. Explain formation of bubbles sometimes noticed in the nitric acid test for albumin.
5. How prove by the urine that a patient has been taking bromids or iodids?

6. Why is the appearance of leucin and tyrosin accompanied by a marked reduction of urea?

7. Why do K salts exceed Na salts, reversing the normal ratio, in urine during starvation?

8. What effect does drinking lemonade have on urinary acidity?

9. Is lithemic urine likely to be more irritating in summer or in winter?

10. What is the significance of freshly passed ammoniacal urine?

11. What object in adding HNO_3 before $AgNO_3$ in determining chlorids?

12. What information does the urine furnish concerning digestion?

13. A drop of urine containing globulin shows an opalescent trail when dropped into distilled water. Explain.

14. How determine the amount of acid salts in gastric juice?

15. Name five drugs which taken internally may give a color to the urine like that of blood.

16. Why does blood from the kidney render the urine smoky?

17. If one gets an albumin-like ring which disappears on heating, what is it?

18. Explain the color-changes in the copper reduction tests for sugar.

19. What are the most certain evidences of kidney disease?

20. How diagnose renal insufficiency?

21. Write equation for the alkaline fermentation of urine.

22. In what disease is the sp. gr. abnormally high with increased quantity of urine? Explain.

23. In what diseases are the sp. gr. and quantity of urine both at times abnormally low? Explain.

24. What is the clinic significance of indicanuria?

25. Mention five points of distinction between a sediment of urates and one of phosphates.

26. Explain the relation of the night excretion to the fact that the urine is especially acid mornings.

27. What change does the urine of acute rheumatism show when pericarditis supervenes?

28. Why does ammoniacal diabetic urine not react well to the copper tests?

29. What kind of sugar is usually found in diabetic urine?

30. Explain greenish-blue discoloration noted in acetic acid and ferrocyanid test for albumin on standing.

31. Why should a meat diet predispose to lithuria, and a carbohydrate diet to oxaluria?

32. How may a uric acid renal calculus become coated with phosphates in the bladder?

33. Why is the odor of urine intensified on warming or by adding a mineral acid?

34. Why must the milk and the gastric juice be exactly neutralized in testing for chymosin?

35. Explain principle of sp. gr. test for urea.

36. How may excess of indican give a deceptive greenish appearance with Gmelin's test for choluria?

37. How could you distinguish a levorotatory action of the urine due to levulose from that depending on proteins, cystin, glycuronic or oxybutyric acid, etc.?

38. How would you treat a sediment composed chiefly of urates in order to render the formed elements visible under the microscope?

39. How could you distinguish a chylous urine from one to which milk had been added?

40. Why does diabetic urine become quickly opalescent?

41. How remove albumins before testing for albumoses and peptons in gastric juice?

42. How may urinary analysis aid in the early diagnosis of measles?

43. Purdy's test with a certain urine shows 6.8 per cent. sugar; polarization, 5.3 per cent. Explain.

44. If a certain urine had a fruity odor, later becoming alcoholic, what would you suspect?

45. Why should the proportion of ammonia be determined in fresh urine only?

46. Why does the urine often contain a reducing substance after the administration of licorice?

47. Why can larger amounts of volatile fatty acids be obtained from decomposing than from fresh urine?

48. What is the most certain test for dextrose in the urine?

49. Would oxybutyric acid be more likely to be found in a fresh or a stale urinary specimen?

50. What effect has the administration of large doses of alkalies or substances forming carbonates upon urinary transparency?

51. What relation does disease of the liver bear to the amount of urea in the urine?

52. A strip of filter-paper moistened with a few drops of NaHO and a drop of $Pb(C_2H_3O_2)_2$ solution, clamped in the neck of a bottle of urine, turns black. What is present?

53. What sort of diet is indicated in acetonuria?

54. Why does the colorless solution, in Purdy's quantitative test for sugar, turn blue again on cooling?

55. What synthetic reaction may take place in the kidneys?

56. How prove urine to be ammoniacal?

57. How prevent deceptive development of gas in non-glycosuric urines with yeast test?

58. About what ratio does the amount of urea in normal urine bear to uric acid?

59. The quantity of urine being insufficient for the urinometer, how could you determine the sp. gr.?

60. What effect should the administration of alkalies have upon the urinary excretion of ammonia and urea?

61. How detect by the urine that a person is a morphin "fiend"?

62. On what various factors does diabetes mellitus depend?

63. How may the ingestion of glycerin give rise apparently to glycosuria?

64. How would you differentiate between a phosphatic and a glycosuric reaction in using the copper reduction test?

65. How might earthy phosphates be mistaken for albumin in the urine, and in what way would you distinguish between the two?

66. Why does the sp. gr. of the urine lessen on fermentation?

67. What protein is present in normal urine?

68. How does the character of the foam on shaking a bottle of urine give evidence of the presence of sugar, bile or albumin?

69. What effect have ingested cereals on the quantity of phosphates in the urine?

APPENDIX.

SOLUBILITY OF COMMON DRUGS AND CHEMICALS AT 15° C.

EXPLANATION.—s. = soluble; ins. = insoluble; f. s., v. s., and sp. = freely very, sparingly soluble; alm. = almost; mis. = miscible; dec. = decomposed.

	WATER. PARTS.	ALCOHOL. PARTS.
Acacia	1	ins.
Acetanilid	200	10
Acetozone	1000	
Acid, benzoic	500	3
" boric	25	15
" cacodylic	s.	s.
" carbolic	20	v. s.
" cinnamic	v. sp.	s.
" citric	0.75	1
" gallic	100	4.5
" oleic	ins.	s.
" oxalic	10	2.5
" salicylic	450	2.5
" sulphanilic	182	
" tannic	6	0.6
" tartaric	0.7	2.5
" trichloracetic	f. s.	f. s.
Aloin	60	25
Alum	10.5	ins.
" burnt	20	ins.
Ammonium benzoate	5	28
" bromid	1.5	150
" carbonate	4	dec.
" chlorid	3	1.5
" iodid	1	9
" valerianate	v. s.	v. s.
Amylene hydrate	8	5
Antimony and potassium tartrate	17	ins.
" oxid	ins.	ins.
Antipyrin (phenazone)	1	1
Apiol	ins.	s.
Apomorphin hydrochlorate	6.8	50
Aristol	ins.	sp.
Arsenic iodid	3.5	10
Arsenous oxid	30 to 80	sp.
Asafetida	emuls.	60 %
Aspidospermin	sp.	0.3
Atropin	600	v. s.
" sulphate	0.4	6.5
Balsam of copaiba	ins.	10
" " Peru	alm. ins.	5
" " Tolu	alm. ins.	v. s.
Benzonaphtol	ins.	s.

SOLUBILITY OF COMMON DRUGS AND CHEMICALS AT 15° C. *(Continued).*

EXPLANATION.—s. = soluble; ins. = insoluble; f. s., v. s., and sp. = freely, very, sparingly soluble; alm. = almost; mis. = miscible; dec. = decomposed.

	WATER, PARTS.	ALCOHOL, PARTS.
Benzosol	ins.	s.
Berberin sulphate	s.	s.
Bismuth and ammonium citrate	v. s.	sp.
" citrate	ins.	ins.
" subcarbonate	ins.	ins.
" subnitrate	ins.	ins.
Bromoform	300	v. s.
Caffein	80	33
" citrate	25	
Calcium bromid	0.7	1
" carbonate	ins.	ins.
" chlorid	1.5	8
" glycerinophosphate	s.	alm. ins.
" hypophosphite	7	ins.
" lactophosphate	s.	ins.
" phosphate	ins.	ins.
" sulphate	400	ins.
Camphor	1300	f. s.
" monobromated	alm. ins.	v. s.
Cerium oxalate	ins.	ins.
Chalk	ins.	ins.
Chloral hydrate	v. s.	v. s.
Chloralamid	10	2.5
Chloralose	170	f. s.
Chloretone	100	v. s.
Chloroform	200	v. s.
Chromic oxid	v. s.	dec.
Chrysarobin	sp.	sp.
Cinchonidin sulphate	100	70
Cinchonin sulphate	70	6
Cocain hydrochlorate	0.5	3.5
Codein	80	v. s.
Colchicin	s.	s.
Coniin	2	2
Copper acetate	15	135
" arsenite	sp.	
" sulphate	2.6	ins.
Cotarnin hydrochlorate (stypticin)	s.	s.
Creolin	(mis.2½%)	s.
Creosote	150	v. s.
" carbonate	ins.	s.
Dermatol	ins.	ins.
Diabetin (levulose)	s.	sp.
Digitalin	ins.	f. s.
Digitoxin	ins.	s.
Dionin	7	2
Diuretin	0.5	
Elaterin	ins.	337
Ergotin	s.	
Ethyl bromid	ins.	s.
" iodid	ins.	s.
Eucain, alpha-	10	3

SOLUBILITY OF COMMON DRUGS AND CHEMICALS AT 15° C. *(Continued).*

EXPLANATION.—s. = soluble; ins. = insoluble; f. s., v. s., and sp. = freely, very, sparingly soluble; alm. = almost; mis. = miscible; dec. = decomposed.

	WATER. PARTS.	ALCOHOL. PARTS.
Eucain, beta-	28	14
Eucalyptol	alm. ins.	s.
Euphorin	ins.	s.
Euquinin	sp.	s.
Europhen	ins.	s
Ferric and ammonium citrate	v. s.	ins.
“ “ potassium tartrate	v. s.	ins.
“ “ quinin citrate	s.	ins.
“ “ strychnin citrate	v. s.	sp.
“ chlorid	v. s.	v. s.
“ citrate	s.	ins.
“ hydrate	ins.	ins.
“ hypophosphite	sp.	ins.
“ lactate	40	alm. ins.
“ phosphate	v. s.	ins.
“ pyrophosphate	v. s.	ins.
“ sulphate	1.8	ins.
“ tartrate	v. s.	ins.
“ valerianate	ins.	f. s.
Fluorescein	s.	
Formaldehyd	v. s.	
Fuchsin	s.	
Glycerin	f. s.	f. s.
Gold and sodium chlorid	v. s.	sp.
Guaiacol	85	f. s.
“ carbonate	ins.	sp.
Heroin hydrochlorate	s.	
Holocain hydrochlorate	50	6
Homatropin hydrobromate	10	133
Hydrastin hydrochlorate	f. s.	f. s.
Hydrastinin hydrochlorate	1	3
Hyoscin hydrobromate	4	15
Ichthyol	v. s.	ins.
Iodin	5000	10
Iodoform	ins.	80
Iodol	ins.	3
Kairin	6	20
Kryofin	600	f. s.
Lactophenin	500	9
Lanolin	mis. 2	80
Lime	750	ins.
Lithium benzoate	4	12
“ bromid	v. s.	v. s.
“ carbonate	80	ins.
“ citrate	2	sp.
“ salicylate	v. s.	v. s.
Losophan	sp.	s.
Lycetol	s.	
Lysol	f. mis.	v. s.
Magnesium carbonate	alm. ins.	ins.
“ oxid	alm. ins.	ins.
“ sulphate	1.5	ins.

SOLUBILITY OF COMMON DRUGS AND CHEMICALS AT 15° C. *(Continued).*

EXPLANATION.—s. = soluble; ins. = insoluble; f. s., v. s., and sp. = freely, very, sparingly soluble; alm. = almost; mis. = miscible; dec. = decomposed.

	WATER. PARTS.	ALCOHOL. PARTS.
Manganese dioxid	ins.	ins.
" sulphate	11	ins.
Menthol	sp.	v. s.
Mercuric chlorid	16	3
" cyanid	13	15
" iodid (red)	alm. ins.	130
" oxid	ins.	ins.
" subsulphate	ins.	ins.
Mercurol (10 per cent. nuclein)	s.	ins.
Mercurous chlorid	ins.	ins.
" iodid (green)	alm. ins.	ins.
Mercury, ammoniated	ins.	ins.
Methacetin	530	s.
Methyl chlorid	4 vol.	35 vol.
Methylene-blue	sp.	50
Morphin acetate	12	68
" hydrochlorate	24	63
" sulphate	24	702
Naphtalin	ins.	15
Naphtol, beta-	1000	75
Nosophen	ins.	ins.
Oils, fixed	ins.	ins.
" volatile	v. sp.	f. s.
Orexin hydrochlorate	v. s.	v. s.
Orthoform	sp.	ins.
Pancreatin	sp.	ins.
Paraldehyd	10	s.
Pelletierin tannate	700	80
Pepsin	100	ins.
Petrolatum	ins.	ins.
Phenacetin	1700	20
Phenocoll hydrochlorate	16	
Phosphorus	ins.	350
Physostigmin (eserin) salicylate	150	12
Picrotoxin (cocculin)	240	9
Pilocarpin hydrochlorate	v. s.	v. s.
Piperazin	v. s.	
Piperin	alm. ins.	30
Plumbic acetate	2.3	21
" iodid	2000	v. sp.
" nitrate	2	v. sp.
" oxid	ins.	ins.
Potassium acetate	0.4	1.9
" and sodium tartrate	1.4	alm. ins.
" bicarbonate	3.2	alm. ins.
" bitartrate	200	v. sp.
" bromid	1.6	200
" carbonate	1	ins.
" chlorate	16.5	v. sp.
" citrate	0.6	v. sp.
" cyanid	2	sp.
" dichromate	10	ins.

SOLUBILITY OF COMMON DRUGS AND CHEMICALS AT 15° C. *(Continued).*

EXPLANATION.—s. = soluble; ins. = insoluble; f. s., v. s., and sp. = freely, very, sparingly soluble; alm. = almost; mis. = miscible; dec. = decomposed.

	WATER. PARTS.	ALCOHOL PARTS.
Potassium ferrocyanid	4	ins.
“ hydrate	0.5	2
“ hypophosphite	0.6	7.5
“ iodid	0.8	18
“ nitrate	4	alm. ins.
“ permanganate	18	dec.
“ sulphite	4	sp.
“ sulphurated	f. s.	sp.
“ tartrate	0.7	alm. ins.
Protargol (8 per cent. Ag)	s.	
Pyoktanin-blue	75	12
Pyridin	mis.	1
Quinidin sulphate	100	8
Quinin	1670	6
“ bisulphate	10	32
“ hydrobromate	54	0.6
“ hydrochlorate	34	3
“ sulphate	740	65
“ valerianate	100	5
Resins	ins.	f. s.
Resorcin	2	s.
Rubidium iodid	s.	
Saccharin (garantose, glusid)	400	30
Salacetol	ins.	15
Salicin	30	60
Salipyrin	250	v. s.
Salol	alm. ins.	10
Salophen	ins.	v. s.
Santonin	sp.	40
Scopolamin hydrobromate	4	15
Silver lactate	20	
“ nitrate	0.8	26
“ oxid	v. sp.	ins.
Soap, green	5 hot	2
Sodium acetate	3	30
“ arsenate	4	v. sp.
“ benzoate	1.8	45
“ bicarbonate	12	ins.
“ bisulphite	4	72
“ borate (borax)	16	ins.
“ bromid	2	16
“ cacodylate	s.	
“ carbonate	1.6	ins.
“ chlorate	1.1	100
“ chlorid	2.8	alm. ins.
“ cinnamate	s.	
“ hydrate	1.7	v. s.
“ hypophosphite	1	30
“ hyposulphite	1.5	ins.
“ iodid	0.6	1.8
“ nitrate	1.3	sp.
“ nitrite	1.5	ins.

SOLUBILITY OF COMMON DRUGS AND CHEMICALS AT 15° C. *(Continued).*

EXPLANATION.—s. = soluble; ins. = insoluble; f. s., v. s., and sp. = freely, very, sparingly soluble; alm. = almost; mis. = miscible; dec. = decomposed.

	WATER. PARTS.	ALCOHOL. PARTS.
Sodium phosphate	6	ins.
" pyrophosphate	12	ins.
" salicylate	1.5	6
" sulphate	2.8	ins.
" sulphite	4	sp.
" sulphocarbolate	6	150
Strontium bromid	v. s.	v. s.
" iodid	v. s.	v. s.
" lactate	4	s.
Strychnin sulphate	31	60
Sugar, cane-	0.5	175
" milk-	6	ins.
Sulphonal	450	50
Sulphur	ins.	ins.
Suprarenal extract	f. s.	
Tannalbin	ins.	ins.
Tannigen	ins.	s.
Terebene	ins.	1
Terpin hydrate	250	10
Thallin sulphate	7	100
Thiocol	s.	sp.
Thiol	mis.	sp.
Thymol	1200	1
Trional	320	s.
Turpentine (rectified oil)	ins.	3
Uranium nitrate	s.	s.
Urethan	1	0.6
Urotropin (formin)	s.	sp.
Veratrin	sp.	3
Xeroform (tribromphenol bismuth)	ins.	ins.
Zinc acetate	3	36
" bromid	v. s.	v. s.
" carbonate	ins.	ins.
" chlorid	0.5	1
" iodid	v. s.	v. s.
" oxid	ins.	ins.
" phosphid	ins.	ins.
" sulphate	0.6	ins.
" sulphocarbolate	5	5
" valerianate	120	40

ARITHMETIC CONSTANTS.

1 Barrel (U. S.) = 31½ gallons = 119.2 liters.
1 Bushel (U. S.) = 2150.42 cubic inches = 32 quarts = 35.243 liters.
1 Calorie = 2.2 thermal units = 425.5 kilogrammeters = 425,500 grammeters = 3077.6 foot-pounds = 1.54 foot-tons.
1 Centimeter = $\frac{1}{100}$ meter = 0.3937 inch.
1 Cubic Centimeter = $\frac{1}{1000}$ liter = 16.23 minims = 0.061 cubic inch — weighs 1 gram at 4° C.

1 Cubic Foot = 1728 cubic inches = 28316.085 cubic centimeters — water weighs 62.32 lbs. avoirdupois at 62° F.
1 Cubic Inch = 266 minims = 16.386 c.c. — water weighs 252.46 grains or 16.372 grams.
1 Cubic Meter (stere) = 1000 liters = 35.315 cubic feet.
1 Dram (Troy, or Apothecary) = 60 grains = 3.888 grams.
1 Fluidram = 60 minims = 3.696 cubic centimeters.
1 Fluidounce (imperial) = 28.4 c.c. = 1.7329 cubic inches — water weighs 437½ grains at 62° F.
1 Fluidounce (U. S. wine measure) = 8 drams = 480 minims = 29.57 c.c. = 1.8047 cu. in. — water weighs 456 grains or 29.57 grams.
1 Foot = 12 inches = 144 lines = 0.30479 meter.
1 Foot-pound = 0.138 kilogrammeter = 13.56 megaergs.
1 Gallon (imperial) = 277.27 cubic inches = 4.543 liters — water weighs 10 pounds (70,000 grains).
1 Gallon (wine) = 8 pints = 231 cubic inches = 3.785 liters — water weighs 8.34 pounds (58,328 grains).
1 Gallon (solid) = 268.8 cubic inches.
1 Grain (Troy) = 0.0648 gram.
1 Gram = 15.4323 Troy grains = weight of 1 c.c. of water at 4° C.
1 Inch = 12 lines = 2.54 centimeters.
1 Kilogram = 1000 grams = 32.1 Troy ounces = 2.2046 avoirdupois pounds = weight of a liter of water.
1 Kilogrammeter = 7.233 foot-pounds.
1 Liter = a cubic decimeter = 1000 c.c. = 33.8 fluidounces = 1.056 wine quarts = 61.027 cubic inches.
1 Meter = 3.28086 feet = 39.37043 inches = about one forty-millionth of earth's meridian.
1 Millimeter = 1000 micromillimeters = $\frac{1}{1000}$ meter = 0.0393 inch (about $\frac{1}{25}$ inch).
1 Minim = 0.0616 c.c. — water weighs 0.95 grain — equals 2 drops of tincture.
1 Ounce (Troy) = 480 grains = 31.1 grams.
1 Ounce (avoirdupois) = 437.5 grains = 28.35 grams.
1 Pint (imperial) = 20 fluidounces = 567.93 cubic centimeters.
1 Pint (U. S. wine) = 16 fluidounces = 473.179 cubic centimeters.
1 Pound (Troy) = 12 ounces = 5760 grains = 0.37324 kilogram.
1 Pound (avoirdupois) = 16 ounces = 7000 grains = 0.45359 kilogram.
1 Quart (imperial) = 40 fluidounces = 69.97 cubic inches = 1.1358 liters.
1 Quart (wine measure) = 32 fluidounces = 58.3 cubic inches = 0.9463 liter.
1 Square Foot = 144 square inches = 0.0929 square meter.
1 Square Meter = 10.7641 square feet.
1 Thermal Unit = 0.45 calorie = 1390 foot-pounds = 0.695 foot-ton.
1 Ton (avoirdupois) = 2000 pounds = 29,167 Troy ounces = 907.2 kilograms.
1 Tonneau = 1,000,000 grams = 1000 kilos = 2204.6 avoirdupois pounds.
1 Yard = 3 feet = 36 inches = 0.9144 meter.

EQUATIONS OF MANUFACTURING CHEMISTRY.

Aluminum.
Chlorid .... $4Al_2O_3 + 12Cl_2 + 3C_2$ (at red heat) $= 4Al_2Cl_6 + 6CO_2$
Hydrate .... $K_2Al_2(SO_4)_4.24H_2O + Na_2CO_3 = Al_2(HO)_6 + Na_2SO_4 + K_2SO_4 + CO_2 + 2H_2SO_4 + 19H_2O$
Potash Alum ..... $H_2Al_2Si_2O_8$ (shale) $+ 3H_2SO_4$ (hot) $+ K_2SO_4 = Al_2K_2(SO_4)_4 + 4H_2O + 2SiO_2$
Sulphate .... $Al_2(HO)_6 + 3H_2SO_4 = Al_2(SO_4)_3 + 6H_2O$

Ammonium.	
Ammonia (for medicinal purposes)	$2NH_4Cl + Ca(HO)_2 = CaCl_2 + 2NH_3 + 2H_2O$
Bromid	$NH_4OH + HBr = NH_4Br + H_2O$
Carbonate	$2(NH_4)_2SO_4 + 2CaCO_3$ (heated in iron retort) $= NH_4HCO_3.NH_4NH_2CO_2$ (official carbonate) $+ NH_3 + H_2O + 2CaSO_4$
Chlorid	NH_4OH (ammoniacal water from gasworks) $+ CaO = NH_3 + Ca(HO)_2$. $NH_3 + HCl = NH_4Cl$
Iodid	$NH_4OH + HI = NH_4I + H_2O$
Nitrate	$HNO_3 + NH_4HO = NH_4NO_3 + H_2O$
Sulphate	$2NH_4HO$ (ammoniacal gas liquor) $+ H_2SO_4 = (NH_4)_2SO_4 + 2H_2O$
Antimonium.	
Chlorid	$Sb_2S_3 + 6HCl = 2SbCl_3$ (solution) $+ 3H_2S$
Oxid	$4SbCl_3.5Sb_4O_6 + 6Na_2CO_3 = 12Sb_2O_3 + 12NaCl + 6CO_2$
Oxychlorid	$24SbCl_3 + 30H_2O = 4SbCl_3.5Sb_4O_6 + 60HCl$
Tartrate of Antimony and Potassium	$4KHC_4H_4O_6 + Sb_4O_6 = 4KSbOC_4H_4O_6 + 2H_2O$
Arsenum.	
Iodid	$As + I_3$ (rubbed together and sublimated) $= AsI_3$
Oxid	As_2 (ores containing As) $+ O_3$ (roasted in air) $= As_2O_3$
Barium.	
Chlorid	$BaSO_4 + 4C$ (fusing) $= BaS + 4CO$. $BaS + 2HCl = BaCl_2 + H_2S$
Hydrate	$BaCO_3$ (heated in current of water) $+ H_2O = Ba(HO)_2 + CO_2$
Nitrate	$BaCO_3 + 2HNO_3 = Ba(NO_3)_2 + CO_2 + H_2O$
Oxids	$Ba(NO_3)_2$ (heated in iron crucible till red fumes cease) $= BaO + N_2O_5$ $BaO + O$ (heating in a stream of dry air or O at 450° C.) $= BaO_2$
Bismuth.	
Subcarbonate	$2Bi(NO_3)_3 + Na_2CO_3 + H_2O = (BiO)_2CO_3.H_2O + 2HNO_2 + 2HNO_3 + 2NaNO_3$
Subnitrate	$Bi(NO_3)_3 + 2H_2O$ (4 parts cold, then 21 boiling) $= BiONO_3.H_2O + 2HNO_3$
Boron.	
Trioxid	$2H_3BO_3$ (heated to redness) $= B_2O_3 + 3H_2O$
Calcium.	
Bromid	$2HBr + CaCO_3 = CaBr_2 + CO_2 + H_2O$
Carbid	$CaO + 3C$ (heated in electric furnace) $= CaC_2 + CO$
Carbonate	$Na_2CO_3 + CaCl_2 = CaCO_3 + 2NaCl$
Chlorid	$2HCl + CaCO_3$ (marble) $= CaCl_2 + CO_2 + H_2O$
Hypochlorite	$Ca(HO)_2 + Cl_2 = CaOCl_2 + H_2O$
Hypophosphite	$3Ca(HO)_2 + 2P_4 + 6H_2O$ (warmed to 40°) $= 3Ca(H_2PO_2)_2 + 2H_3P$
Oxid	$CaCO_3$ (burned) $= CaO + CO_2$
Phosphate	$3CaCl_2 + 2NH_4OH + 2Na_2HPO_4.12H_2O = Ca_3(PO_4)_2 + 2NH_4Cl + 4NaCl + 26H_2O$
Sulphid	$CaSO_4 + 2C$ (charcoal heated) $= CaS + 2CO_2$
Carbon.	
Dioxid	$CaCO_3$ (marble-dust) $+ 2HCl = CaCl_2 + H_2O + CO_2$
Disulphid	C (charcoal) $+ S_2$ (heat to redness) $= CS_2$

Cerium.
Oxalate ....$Ce_2Cl_6 + 3(NH_4)_2C_2O_4 = Ce_2(C_2O_4)_3 + 6NH_4Cl$

Chromium.
Sesquioxid ....$K_2Cr_2O_7 + S$ (heat) $= K_2SO_4 + Cr_2O_3$
Trioxid ....$K_2Cr_2O_7 + 2H_2SO_4 = 2CrO_3 + 2KHSO_4 + H_2O$

Copper.
Arsenite ....$CuSO_4 + KH_2AsO_3 = CuHAsO_3 + KHSO_4$
Nitrate ....$3Cu + 8HNO_3 = 3Cu(NO_3)_2 + N_2O_2 + 4H_2O$
Oxid ....$CuSO_4 + 2KHO = Cu(HO)_2 + K_2SO_4$
$Cu(HO)_2$ (boiled) $= CuO + H_2O$
Sulphate ....$CuO + H_2SO_4 = CuSO_4 + H_2O$

Gold.
Chlorid ....$Au + Cl_3$ (nitrohydrochloric acid) $= AuCl_3$

Hydrogen.
Arsenate ....$As_2O_3 + 2H_2O + 2HNO_3 = 2H_3AsO_4 + N_2O_3$
Bromid ....$3KBr + H_3PO_4$ (heated together) $= 3HBr + K_3PO_4$
Chlorid ....$2NaCl + H_2SO_4 = Na_2SO_4 + 2HCl$
Cyanid ....$K_4Fe(CN)_6 + 5H_2SO_4 = 6HCN + FeSO_4 + 4KHSO_4$
Dioxid ....$BaO_2 + 2HF = H_2O_2 + BaF_2$
Fluorid ....$CaF_2 + H_2SO_4 = CaSO_4 + 2HF$
Iodid ....$2I_2 + 2H_2S + H_2O = 4HI + S_2 + H_2O$
Lactate ....$Ca(C_3H_5O_3)_2 + H_2C_2O_4 = 2HC_3H_5O_3 + CaC_2O_4$
Nitrate ....$KNO_3 + H_2SO_4 = HNO_3 + KHSO_4$
Orthoborate ......$Na_2B_4O_7 + 2HCl + 5H_2O = 4H_3BO_3 + 2NaCl$
Phosphate ....$3P + 5HNO_3 + 2H_2O = 3H_3PO_4 + 5NO$
Salicylate ....$NaC_7H_5O_3 + HCl = HC_7H_5O_3 + NaCl$
Sulphate ....$2SO_2 + N_2O_4 + 2H_2O = 2H_2SO_4 + N_2O_2$
Sulphid ....$FeS + H_2SO_4 = FeSO_4 + H_2S$
Sulphite ....$SO_2 + H_2O = H_2SO_3$
Tartrate ....$CaC_4H_4O_6 + H_2SO_4 = H_2C_4H_4O_6 + CaSO_4$

Iron.
Chlorids ....$Fe + 2HCl = FeCl_2 + H_2$. $Fe_2O_3 + 6HCl = Fe_2Cl_6 + 3H_2O$
Iodid ....$2I_2 + Fe_2$ (filings in warm water) $= 2FeI_2$
Carbonate ....$Na_2CO_3 + FeSO_4 = FeCO_3 + Na_2SO_4$
Hydrate ....$Fe_2Cl_6 + 6NH_4OH = Fe_2(OH)_6 + 6NH_4Cl$
Nitrate ....$Fe_2(OH)_6 + 6HNO_3 = 6H_2O + Fe_2(NO_3)_6$
Sulphates ....$Fe + H_2SO_4$ (dilute) $= FeSO_4 + H_2$. $Fe_2O_3 + 3H_2SO_4 = Fe_2(SO_4)_3 + 3H_2O$
Sulphid ....$Fe + S$ (fused together) $= FeS$

Lead.
Acetate ....$PbO + 2HC_2H_3O_2 = Pb(C_2H_3O_2)_2 + H_2O$
Basic Carbonate ..Dutch method: $3Pb + O_2$ (air) $+ CO_2$ (manure or tan-bark) $+ 2HC_2H_3O_2$ (vapors) $= Pb_3O_2.2C_2H_3O_2 + 2CO_2 + H_2O + O + H_2 = (PbCO_3)_2.Pb(HO)_2 + 2HC_2H_3O_2$
French method: $3PbO + 3Pb(C_2H_3O_2)_2 = Pb_3O(C_2H_3O_2)_4 + Pb_3O_2(C_2H_3O_2)_2$. These and $2CO_2 + H_2O = (PbCO_3)_2Pb(HO)_2 + 3Pb(C_2H_3O_2)_2$
Chlorid ....$Pb(NO_3)_2 + 2HCl = PbCl_2 + 2HNO_3$
Iodid ....$Pb(NO_3)_2 + 2KI = PbI_2 + 2KNO_3$
Monoxid ....$PbCO_3$ (heated to low redness) $= PbO + CO_2$
Nitrate ....$PbO + 2HNO_3 = Pb(NO_3)_2 + H_2O$
Oleate ....$3PbO + 3H_2O + 2C_3H_5(C_{18}H_{33}O_2)_3$ (olive-oil) $= 2C_3H_5(HO)_3 + 3Pb(C_{18}H_{33}O_2)_2$
Subacetate ....$PbO + Pb(C_2H_3O_2)_2 = Pb_2O(C_2H_3O_2)_2$

Lithium.
Bromid ....$Li_2CO_3 + 2HBr = 2LiBr + CO_2 + H_2O$

Carbonate .... Li_4SiO_4 (lepidolite) $+ H_2SO_4 + H_2O + Ca(HO)_2 = 4LiOH$, etc.

$4LiOH + 2(NH_4)_2CO_3 = 2Li_2CO_3 + 4NH_4OH$

Chlorid .... $Li_2CO_3 + 2HCl = 2LiCl + CO_2 + H_2O$

Citrate .... $3Li_2CO_3 + 2H_3C_6H_5O_7 = 2Li_3C_6H_5O_7 + 3H_2O + 3CO_2$

Salicylate .... $Li_2CO_3 + 2HC_7H_5O_3 = 2LiC_7H_5O_3 + H_2O + CO_2$

Magnesium.

Carbonate .... $5MgSO_4 + 5Na_2CO_3 + 6H_2O = (MgCO_3)_4.Mg(HO)_2.5H_2O$ (heavy or official carbonate) $+ 5Na_2SO_4 + CO_2$

Citrate .... $3(MgCO_3)_4.Mg(HO)_2.3H_2O + 10H_3C_6H_5O_7 + 49H_2O = 5Mg_3(C_6H_5O_7)_2.14H_2O + 12CO_2$ (more CO_2 is produced by dropping in crystals of $KHCO_3$ just before corking and wiring).

Hydrate .... $MgSO_4 + 2NaHO = Mg(HO)_2 + Na_2SO_4$

Oxid .... $(MgCO_3)_4.Mg(HO)_2.5H_2O$ (ignited) $= 5MgO$ (heavy, or official) $+ 6H_2O + 4CO_2$

Sulphate .... $MgCO_3 + H_2SO_4 = MgSO_4 + CO_2 + H_2O$

Manganese.

Sulphate .... $MnO_2 + H_2SO_4 = MnSO_4 + H_2O + O$

Mercury.

Ammoniated ...... $HgCl_2 + 2NH_4HO = NH_2HgCl + NH_4Cl + 2H_2O$

Chlorids .... $Hg_2SO_4 + 2NaCl = Hg_2Cl_2 + Na_2SO_4$

$HgSO_4 + 2NaCl$ (sublime) $= HgCl_2 + Na_2SO_4$

Cyanid .... $HgO + 2HCN = Hg(CN)_2 + H_2O$

Iodids .... $Hg_2(NO_3)_2 + 2KI = Hg_2I_2 + 2KNO_3$

$HgCl_2 + 2KI = HgI_2 + 2KCl$

Nitrate .... HgO (red) $+ 2HNO_3 + H_2O = Hg(NO_3)_2 + 2H_2O$

Oxid .... $HgCl_2 + 2NaHO = HgO$ (yellow) $+ 2NaCl + H_2O$

$Hg_2(NO_3)_2 + 2KHO = Hg_2O$ (black) $+ 2KNO_3 + H_2O$

$3Hg + 8HNO_3 = 3Hg(NO_3)_2 + 2NO + 4H_2O$

$Hg(NO_3)_2$ (heated) $= HgO$ (red) $+ 2NO_2 + O$

Subsulphate ...... $3Hg + H_2SO_4 + HNO_3 + H_2O = Hg(HgO)_2SO_4$, etc.

Sulphate .... $Hg + 2H_2SO_4 = HgSO_4 + SO_2 + 2H_2O$

Nitrogen.

Ammonia .... $(NH_4)_2SO_4 + Ca(HO)_2 = CaSO_4 + 2NH_3 + 2H_2O$

Dioxid .... $3Cu + 8HNO_3 = 3Cu(NO_3)_2 + N_2O_2 + 4H_2O$

Monoxid .... NH_4NO_3 (heated) $= N_2O + 2H_2O$

Platinum.

Chlorid .... $Pt + 2Cl_2$ (aqua regia) $= PtCl_4$

Potassium.

Acetate .... $K_2CO_3 + 2HC_2H_3O_2 = 2KC_2H_3O_2 + H_2O + CO_2$

Arsenite .... $As_2O_3 + 2KHCO_3 + H_2O = 2KH_2AsO_3 + 2CO_2$

Bicarbonate ...... $K_2CO_3 + CO_2 + H_2O = 2KHCO_3$

Bromid .... $FeBr_2 + K_2CO_3 = 2KBr + FeCO_3$

Chlorate .... $6Ca(HO)_2 + 6Cl_2 = 5CaCl_2 + Ca(ClO_3)_2 + 6H_2O$

$Ca(ClO_3)_2 + 2KCl = 2KClO_3 + CaCl_2$

Chlorid .... $K_2CO_3 + 2HCl = 2KCl + H_2O + CO_2$

Chromate .... $2FeOCr_2O_3 + 4K_2CO_3 + 7O = Fe_2O_3 + 4CO_2 + 4K_2CrO_4$

Cyanid .... $K_4Fe(CN)_6 + K_2CO_3 = 5KCN + KCNO + CO_2 + Fe$

Dichromate .... $2K_2CrO_4 + H_2SO_4 = K_2Cr_2O_7 + K_2SO_4 + H_2O$

Ferricyanid .... $2K_4Fe(CN)_6 + Cl_2 = 2K_3 Fe(CN)_6 + 2KCl$

Ferrocyanid ...... $4C + 2N$ (animal scrap) $+ K_2CO_3 = 2KCN + 3CO$

$6KCN + FeS = K_4Fe(CN)_6 + K_2S$

Hydrate ....$K_2CO_3 + Ca(HO)_2 = 2KHO + CaCO_3$
Hypophosphite ....$Ca(H_2PO_2)_2 + K_2CO_3 = 2KH_2PO_2 + CaCO_3$
Iodid ....$Fe_2I_6 + 3K_2CO_3 + 3H_2O = 6KI + 3CO_2 + Fe_2(HO)_6$
$6KOH + 3I_2 = 5KI + KIO_3 + 3H_2O$
Nitrate ....$NaNO_3 + KCl = KNO_3 + NaCl$
Permanganate ....$3K_2MnO_4 + 2CO_2 = K_2Mn_2O_8 + MnO_2 + 2K_2CO_3$
Sulphate ....$2KNO_3 + H_2SO_4 = 2HNO_3 + K_2SO_4$
Tartrate of K and Na ....$2KHC_4H_4O_6 + Na_2CO_3 = 2KNaC_4H_4O_6 + CO_2 + H_2O$

Silver.
Bromid ....$AgNO_3 + KBr = AgBr + KNO_3$
Iodid ....$AgNO_3 + KI = AgI + KNO_3$
Nitrate ....$3Ag + 4HNO_3 = 3AgNO_3 + 2H_2O + NO$
Oxid ....$2AgNO_3 + 2NaHO = Ag_2O + 2NaNO_3 + H_2O$

Sodium.
Acetate ....$NaHCO_3 + HC_2H_3O_2 = NaC_2H_3O_2 + CO_2 + H_2O$
Arsenate ....$As_2O_3 + 2NaNO_3 + Na_2CO_3 = Na_4As_2O_7 + CO_2 + N_2O_3$
$Na_4As_2O_7 + 15H_2O$ (to crystallize) $= 2(Na_2HAsO_4.7H_2O)$
Benzoate ....$HC_7H_5O_2 + NaHCO_3 = NaC_7H_5O_2 + CO_2 + H_2O$
Bicarbonate ......$Na_2CO_3 + CO_2 + H_2O = 2NaHCO_3$
Bisulphite ....$Na_2CO_3 + 2SO_2 + H_2O = 2NaHSO_3 + CO_2$
Bromid ....$FeBr_2 + Na_2CO_3 = FeCO_3 + 2NaBr$
Carbonate ....Leblanc process: $NaCl + H_2SO_4 = NaHSO_4 + HCl$
$NaHSO_4 + NaCl = Na_2SO_4 + HCl$
$Na_2SO_4 + 4C = Na_2S + 4CO$
$Na_2S + CaCO_3 = Na_2CO_3 + CaS$
Solvay's ammonia-soda process: $NaCl + NH_3 + CO_2 + H_2O = NaHCO_3 + NH_4Cl$. $2NaHCO_3$ (heated) $= Na_2CO_3 + CO_2 + H_2O$
Hydrate ....$Na_2CO_3 + Ca(HO)_2 = 2NaHO + CaCO_3$
Hypochlorite ......$Ca(ClO)_2 + CaCl_2 + 2Na_2CO_3 = 2NaClO + 2NaCl + 2CaCO_3$
Hypophosphite ....$Na_2CO_3 + Ca(PH_2O_2)_2 = 2NaPH_2O_2 + CaCO_3$
Iodid ....$6NaHO + 3I_2 = 5NaI + NaIO_3 + 3H_2O$
Nitrite ....$NaNO_3 + Pb$ (heat in Fe vessel) $= NaNO_2 + PbO$
Phosphate ....$Na_2CO_3 + H_3PO_4$ (till faintly alkaline) $= Na_2HPO_4 + CO_2 + H_2O$
Pyrophosphate ....$2Na_2HPO_4$ (heated to 250°) $= Na_4P_2O_7 + H_2O$
Salicylate ....$NaHO + HC_7H_5O_3 = NaC_7H_5O_3 + H_2O$
Silicate ....$4SiO_2 + Na_2CO_3 + C$ (fused together) $= Na_2Si_4O_9 + CO_2 + C$
Sulphite ....$2NaHSO_3 + Na_2CO_3 = 2Na_2SO_3 + CO_2 + H_2O$
Sulphocarbolate ...$Na_2CO_3 + 2C_6H_5HSO_3 = 2NaC_6H_4HSO_3 + H_2O + CO_2$
Thiosulphate ("Hyposulphite") ....$Na_2SO_3 + S$ (boiled together) $= Na_2S_2O_3$

Strontium.
Bromid ....$SrCO_3 + 2HBr = SrBr_2 + CO_2 + H_2O$
Iodid ....$SrCO_3 + 2HI = SrI_2 + CO_2 + H_2O$
Lactate ....$2HC_3H_5O_3 + SrCO_3 = Sr(C_3H_5O_3)_2 + H_2O + CO_2$
Nitrate ....$SrCO_3 + 2HNO_3$ (dilute) $= Sr(NO_3)_2 + H_2O + CO_2$

Sulphur.
Dioxid ....$S_2 + 2O_2$ (burn) $= 2SO_2$
Trioxid ....$2SO_2 + O_2$ (with aid of red-hot Pt sponge) $= 2SO_3$

Tin.	
Chlorids	$Sn + 2HCl$ (hot) $= SnCl_2 + H_2$ $Sn + 2HgCl_2$ (distilled together) $= SnCl_4 + Hg_2$
Zinc.	
Acetate	$ZnO + 2HC_2H_3O_2 = Zn(C_2H_3O_2)_2 + H_2O$
Bromid	$Zn + Br_2 + H_2O$ (warmed gently) $= ZnBr_2 + H_2O$
Carbonate	$5(ZnSO_4.7H_2O) + 5(Na_2CO_3.10H_2O) = 2ZnCO_3.3Zn(HO)_2$ (basic carbonate) $+ 5Na_2SO_4 + 3CO_2 + 82H_2O$
Chlorid	$ZnO + 2HCl = ZnCl_2 + H_2O$
Iodid	$Zn + I_2$ (heated together) $= ZnI_2$
Oxid	$2ZnCO_3.3Zn(HO)_2$ (basic carbonate heated to low redness) $= 5ZnO + 2CO_2 + 3H_2O$
Phosphid	$3Zn_2$ (powdered and heated) $+ P_4$ (vapor) $= 2Zn_3P_2$
Sulphate	$ZnO + H_2SO_4 = ZnSO_4 + H_2O$
Valerianate	$ZnSO_4 + 2NaC_5H_9O_2 = Zn(C_5H_9O_2)_2 + Na_2SO_4$

ORES, ROCKS, AND MINERALS.

Aluminum: Corundum or adamant spar, Al_2O_3 [emery, granular; ruby (colored with Cr), amethyst, and sapphire (colored with Co), crystalline]; spinelle, $MgO + Al_2O_3$; diaspore, $Al_2O_2(HO)_2$; *bauxite*, $Al_2O_2(HO)_4 + Fe_2O_3$; gibbsite, $Al_2(HO)_6$; cryolite, $Al_2F_6.6NaF$; alunite, $H_6KAl_3S_2O_{14}$; turquoise, $(Al_2O_3)_2$, $P_2O_5.5H_2O$ colored with a salt of Cu; silicated rocks, such as kaolin or porcelain clay, Al_2O_3, $2SiO_2.2H_2O$, rotten-stone (with organic matter), slate, marl, basalt, granite or laminated talc, hornblende, emerald, aluminum garnet; topaz, $Al_2SiO_4F_2O$; and feldspar (silicates of Al and K, or Ca and Na) as *orthoclase*, $KNaAlSi_3O_8$; and albite, $NaAlSi_3O_8$; garnet, $(CaMgFeMn)_3.Al_2Si_3O_{12}$; cyanite, $(AlO)_2SiO_3$.

Ammonium: Mascagnite, $(NH_4)_2SO_4$.

Antimony: *Stibnite*, Sb_2S_3; senarmonite (octahedra) and valentinite (rhombic prisms of Sb_2O_3); cervantite, or antimony ochre, Sb_2O_4.

Arsenic: White arsenic, As_2O_3; orpiment, As_2S_3; realgar, As_2S_2; *arsenical iron*, $FeAs_2$; arsenical pyrites or *mispickel*, $FeAs_2FeS_2$.

Barium: *Heavy spar*, $BaSO_4$; *witherite*, $BaCO_3$; barytocelestite, $(BaSrCa)(SO_4)_3$; barytocalcite, $(BaCa)(CO_3)_2$; psilomelane, $MnBaO_2 + MnO_2$.

Beryllium: Beryl, $3BeSiO_3$, $Al_2(SiO_3)_3$ (green = emerald; bluish green = aquamarine); phenacite, Be_2SiO_4; chrysoberyl, BeO, Al_2O_3.

Bismuth: Bismuthite, Bi_2S_3; bismuth-ocher, Bi_2O_3.

Boron: *Borax*, $Na_2B_4O_7.10H_2O$; *boric acid*, H_3BO_3; borocalcite, $CaB_4O_7.4H_2O$; boronatrocalcite, $Na_2B_4O_7$, $2CaB_4O_7.18H_2O$; boracite (stassfurtite), $(MgO)_6(B_2O_5)_8MgCl_2$; eremeeffite, $AlBO_3$; datholite, $(CaO)_2(SiO_2)_2B_2O_3.H_2O$; ulksite, $BNa(CO_3)_2$.

Cadmium: Greenockite, CdS chiefly.

Calcium: *Carbonate*, $CaCO_3$ (limestone, marble, chalk, calcite, arragonite, coral, marl, shells); *dolomite*, $MgCO_3$, $CaCO_3$; *fluorspar*, CaF_2; anhydrite, $CaSO_4$; selenite (crystalline) and alabaster or *gypsum*, $CaSO_4.2H_2O$; syngenite, $CaSO_4.K_2SO_4.H_2O$; wollastonite, $CaSiO_3$; sombrerite, $Ca_3(PO_4)_2$; apatite (phosphorite), $Ca_3(PO_4)_2$, $CaCl_2$; polyhalite, $2CaSO_4.MgSO_4.K_2SO_4.2H_2O$; osteolite, $Ca_3(PO_4)_2$, CaF_2—a fossil deposit; nearly all silicated rocks.

Cerium: Cerite, $H_3(Ce,La,Di)_3(Ca,Fe)Si_3O_{12}$. Monazite sand.

Cesium: Pollux or pollucite, $H_2Cs_4Al_4Si_9O_{27}$.

Chromium: Chromite or chrome-iron ore, FeO,Cr_2O_3; crocoisite, $PbCrO_4$.

Cobalt: Linneite, Co_3S_4; tin-white cobalt, or cobalt speiss, $CoAs_2$;

cobaltite or cobalt-glance, $CoAs_2,CoS_2$; cobalt-bloom, $Co_3(AsO_4)_2$; smaltite or speiss-cobalt, $(CoFeNi)As_2$; erythrite, $Co_3As_2O_8.8H_2O$.

Copper: *Red copper ore* or cuprite, Cu_2O; black oxid, CuO; *copper glance* or chalcocite, Cu_2S; malachite, $CuCO_3,Cu(HO)_2$; azurite, $(CuCO_3)_2,Cu(HO)_2$; *copper pyrites* (bornite; chalcopyrite), Cu_2FeS_2 or $Cu_2S.Fe_2S_3$; covellite, or indigo copper, CuS; variegated copper ore, Cu_3FeS_3; chalcanthet, $CuSO_4$; libethenite, HCu_2PO_5; tagilite, $Cu_3(PO_4)_2,Cu(HO)_2.2H_2O$.

Gold: Electrum (gold mixed with more than 36 per cent. of silver); sylvanite, $(AgAu)Te_2$.

Iron: *Iron pyrites* ("fool's gold") or coal brasses, FeS_2; *red hematite* or specular iron ore, Fe_2O_3; *magnetite* or lodestone, Fe_3O_4; brown ironstone, $Fe_4H_6O_9$; *limonite* or brown hematite, $Fe_2(HO)_6$; *siderite* or spathic ore, $FeCO_3$; wolframite, $FeMnWO_4$; vivianite, $Fe_3(PO_4)_2.8H_2O$; arsenopyrite (sulpharsenite); pyrrhotite, Fe_8S_9; chrysolite, $(FeMg)_2SiO_4$; franklinite, $FeOZnOMnO.Fe_2O_3Mn_2O_3$; göthite (cryst), $FeO.OH$.

Lead: *Galena*, PbS; cerussite, $PbCO_3$; anglesite, $PbSO_4$; wulfenite, $PbMoO_4$; pyromorphite, $Pb_3(PO_4)_2$; crocoisite, $PbCrO_4$; cotunite, $PbCl_2$.

Lithium: Petalite, $LiAlSi_4O_{10}$; spodumene, $LiAlSi_2O_6$; lepidolite, $HKLiAl_2Si_3O_{10}F$.

Magnesium: Mineral periclase, MgO; bischofite, $MgCl_2.6H_2O$; *magnesite*, $MgCO_3$; *dolomite*, $MgCO_3,CaCO_3$; *carnallite*, $KCl.MgCl_2.6H_2O$; kieserite, $MgSO_4.H_2O$; reichardtite, $MgSO_4.7H_2O$; leonite, $K_2Mg(SO_4)_2.4H_2O$; spinel, $MgAl_2Fe_2O_4$; silicates: talc (soapstone), $H_2Mg_3Si_4O_{12}$; potstone; asbestos (earth flax); meerschaum.

Manganese: *Pyrolusite*, MnO_2; *psilomelane*, H_4MnO_5; braunite, Mn_2O_3; manganite, $Mn_2O_3 + H_2O$; hausmannite, Mn_3O_4; manganese spar or rhodochrosite, $MnCO_3$; manganese blende, MnS; haverite, MnS_2; wad or bog manganese (impure peroxid in clay); rhodonite, $MnSiO_3$.

Mercury: *Cinnabar*, HgS; horn quicksilver, $Hg_2Cl_2 + Hg_2I_2$; natural amalgam, $HgAg$.

Molybdenum: Molybdenite, MoS_2; wulfenite, $PbMoO_4$; trioxid, MoO_3.

Nickel: Garnierite or genthite $(NiMgO)_5(SiO_2)_4$; nickel glance, NiS_2, $NiAs_2$; magnetic pyrites or nickeliferous pyrrhotite (Fe, Ni, and S); millerite, NiS; niccolite or arsen nickel, $NiAs$; bunsenite, NiO; gerstorfite, $NiCoAsS$; chloanthite, $NiCoFeAs_2.6H_2O$.

Potassium: *Niter*, KNO_3; *carnallite*, $MgCl_2,KCl$; kainite, $MgSO_4$, $KCl.3H_2O$; schoenite, K_2SO_4, $MgSO_4.6H_2O$; sylvite, KCl; glaserite, $K_3Na(SO_4)_2$; langbeinite, $K_2Mg_2(SO_4)_3$; silicates (potash-feldspar, analcime, granite, syenite, gneiss, micaceous schist).

Silicon: *Silica*, SiO_2: rock crystal or quartz (crystalline—tripoli, onyx, bath-brick, sandstone, amethyst, carnelian), tridimite (crystalline), chalcedony (amorphous—agate, jasper, flint), opal and geyserite (hydrated oxids), silicified wood and kieselguhr (diatomaceous earth); *silicated rocks* (clays, slates, feldspars, mica, meerschaum, serpentine, porphyry, basalt, asbestos, granite, gneiss, syenite, pumice, tourmaline, pyroxene, amphibole, etc.). Smoky quartz, or cairngorm, is colored with organic matter; amethysts (SiO_2) colored with oxids of Mn or Fe.

Silver: *Argentite*, or silver glance, Ag_2S (nearly always with galena); horn silver or cerargyrite, $AgCl$; iodid and bromid of silver; proustite, Ag_3AsS_3; pyrargyrite (with Sb_2S_3); hessite (Ag_2Te); ruby silver (proustite, $Ag_2S.As_2S_3$; pyrargyrite, $Ag_2S.Sb_2S_3$); tetrahedrite, or gray copper ore, $4(Cu_2Ag_2FeHg)S.Sb_2S_3$; stephanite and stromeyerite are also silver minerals.

Sodium: Crude deposits of $NaNO_3$ in dry regions of South America. *Rock-salt*, $NaCl$; Chili saltpeter, $NaNO_3$; loeweite, $Na_2Mg\ (SO_4)_2.$-

$2H_2O$; astrakanite, $Na_2Mg(SO_4)_2.4H_2O$; albite, $NaAlSi_3O_8$; cryolite, $Al_2F_6,6NaF$; thenardite, Na_2SO_4; mirabilite, $Na_2SO_4.10H_2O$. Natrolite is $Na_2O,Al_2O_3,3SiO_2.2H_2O$.

Strontium: Strontianite, $SrCO_3$; celestine or celestite, $SrSO_4$.

Tellurium: Sylvanite, or graphic tellurium, contains about 24 per cent. gold; calaverite, $AuTe_2$, about 4 per cent. gold; nagyagite, or foliate tellurium, $(AgPbAu)Te_2$, from 5 to 9 per cent. gold. Iron pyrites are nearly always auriferous.

Tin: *Cassiterite* or tin-stone, SnO_2 (vein- or mine-tin and stream-tin); sulphid.

Uranium: Uraninite or pitchblende, $(U,Pb_2)_3\ (UO_6)_2$ (about 80 per cent.), with Fe and sometimes Mg and Sr; carnotite (20 per cent. Va oxid and 60 per cent. U oxid); samarskite (6 to 10 per cent. U oxids); autunite (about 60 per cent. U oxids with Ag, Sn and Fe ores); gummite (60 per cent. U oxids); thorogummite (20 per cent. U oxid and 40 per cent. Th oxid).

Zinc: *Zinc blende* or sphalerite, ZnS; calamine, $H_2Zn_2SiO_5$; smithsonite, $ZnCO_3$; zincite or red oxid, ZnO; franklinite, (FeMnZn), $(FeMn)_2O_9$.

POPULAR AND ALCHEMIC NAMES.

Abercrombie's Lotion. Infusion of tobacco, 1 in 200.

A. C. E. Anesthetic mixture of 1 volume of absolute alcohol, 2 volumes of chloroform, and 3 volumes of pure ether.

Acid of sugar. Oxalic acid.

Aerugo. Verdigris.

After-damp. Carbon dioxid in mines following fire-damp explosions.

Aich's Metal. Alloy of Fe and Zn used for casting cannon.

Alabastrine, or Albocarbon. Naphthalene.

Algaroth Powder. Antimony oxychlorid, SbOCl.

Alkermes Mineral. Sulphureted antimony, Sb_2S_3.

Alleluia. Wood-sorrel, *Oxalis acetosella.*

Alum Lake. Commercial sulphate, $Al_2(SO_4)_3.18H_2O$.

Alum Silver. A strong, light alloy used in some parts of chemic apparatus.

Amidon. Starch.

Ammonia Liniment. A mixture of cottonseed-oil and ammonia-water.

Antichlor. Sodium thiosulphate, or "hyposulphite," used in removing excess of Cl in bleaching operations.

Antifebrin. Trade name of acetanilid.

Antifriction Metal. Any alloy having a low coefficient of friction; hence used for bearing surfaces; Babbitt metal is an example.

Apple-oil. Amyl valerianate.

Aqua Fortis. Crude nitric acid.

Aqua Phagedenica. Mercuric oxid; yellow wash.

Aqua Regia. Nitromuriatic acid.

Aqua Reginæ. Nitrosulphuric acid; used to dissolve silver.

Aqua Sedativa. Ammonia-water, 2 oz.; spt. camphor, 1½ dr.; NaCl, 1 oz; water to make a pint.

Aqua Vitæ. Brandy.

Aquila Alba. Old name for calomel.

Argentum Vivum. Native mercury.

Argols. Crude cream of tartar from wine-casks.

Astral-oil. Kerosene.

Azote. Nitrogen.

Azotic Acid. Nitric acid.

Baking Soda. Sodium bicarbonate.

Baldwin's Phosphorus. Calcium nitrate: heated and exposed to sunshine, is luminous in the dark.

Balsam of Soap. Soap liniment.

Balsam of Sulphur. A solution of S in olive-oil.

Barilla. Ashes of sea-plants.

Basham's Mixture. Mist. ferri et ammon. acet.; contains tinct. ferri chloridi, ammon. acet. and acetic acid, dissolved in a sweetened elixir of orange.

Basilicon Ointment. Resin ointment: olive-oil, yellow wax, resin, and Burgundy pitch.

Basyl. The plus radical.

Battley's Solution. Liquor opii sedativus; is 50 per cent. laudanum.

Bay Rum. Spiritus myrciæ.

Bengal Fires. Red: Powdered shellac, 1; $Sr(NO_3)_2$, 5; powdered Mg, 25 parts. Green: Powdered shellac, 1; $Ba(NO_3)_2$, 5; powdered Mg, 25 parts.

Berlin Green. A complex mixture of cyanids of iron.

Berlin Red. Colcothar, or ferric oxid.

Berthollet's Salt. $KClO_3$.

Bestuchuf's Tincture. An ethereal solution of $FeCl_3$.

Bibron's Antidote. A solution of KI, $HgCl_2$, Br, alcohol and water.

Bichlorid of Gold. $AuCl_3.NaCl$.

Bismarck Brown. Vesuvin, canelle, anilin brown, leather brown, cinnamon brown, golden brown, English brown, Manchester brown; used to color wines.

Bitter Earth. Magnesia.

Bitter Salts. Epsom or English salts, $MgSO_4$.

Bittern. Mother-liquor remaining after evaporation and crystallization of NaCl from sea-water.

Black Antimony. Antimony trisulphid, Sb_2S_3.

Black Ash. Impure Na_2CO_3 mixed with carbon.

Black Draught. Compound infusion of senna.

Black Drop. Guttæ nigræ; vinegar of opium.

Black Flux. A mixture of C and K_2CO_3 made by igniting cream of tartar with one-half its weight of niter.

Black Lead. Plumbago, graphite; used for lead-pencils.

Black Salts. Wood lye evaporated nearly to dryness.

Black Wash. A mixture of calomel and lime-water, Hg_2O.

Blancard's Pills. Pil. ferri iodidi coated with balsam of Tolu.

Blaud's Pill. Ferrous carbonate with an alkaline sulphate.

Bleaching Powder. A mixture of calcium chlorid and hypochlorite.

Blende. Various native sulphids.

Blister Copper. Crude copper obtained by roasting a mixture of Cu_2O and Cu_2S.

Blondine. Hydrogen peroxid for bleaching hair.

Blue Mass. Mercurial pill.

Blue Ointment. Mercurial ointment.

Blue-stone, or Blue Vitriol. Cupric sulphate, Roman vitriol.

Bole. Soft clay colored red by ferric oxid.

Bone-black. Carbon and $Ca_3(PO_4)_2$.

Bone-phosphate. Calcium phosphate, $Ca_3(PO_4)_2$.

Borax. Sodium tetraborate $Na_2B_4O_7$.

Boreal. North pole of magnetic needle.

Brandy. Spiritus vini Gallici.

Brimstone. Roll sulphur.

British Gum. Dextrin made by heating starch with water under pressure.

Brown Mixture. Mist. glycyrrhizæ comp.; paregoric 120, wine of antimony 60, in 1000 c.c. water, with licorice, etc.

Brunswick Green. Oxychlorid of copper.

Burnett's Disinfecting Fluid. Solution of zinc chlorid (205 to 230 gr. per oz.).

Burow's Solution. Chief constituent is aluminum acetate.

Butter of Antimony, Bismuth, or Zinc. The chlorids of these metals.

Butter of Paraffin. Petrolatum.

Calcimine. A wash for walls and ceilings, made of whiting, glue, and water, and often tinted.

Calcined Magnesia. MgO from burning of $MgCO_3$.

Calcined Mercury. HgO.

Calomel. Mercurous or mild chlorid of mercury.

Camphene. Oil of turpentine.

Camphoid. A mixture of 1 part of pyroxylon and 20 each of camphor and absolute alcohol.

Canada Pitch. Hemlock-pitch from hemlock-spruce, *Abies Canadensis*.

Canquoin's Paste. $ZnCl_2$ mixed with gypsum and water.

Canton's Phosphorus. Luminous paint, CaS.

Caput Mortuum. Impure Fe_2O_3 left after igniting FeS_2 or $FeSO_4$.

Caramel. Burnt sugar.

Carbolic Acid. Phenyl hydrate, or phenol, C_6H_5HO.

Carron-oil. A mixture of linseed-oil and lime-water for burns; same as lime liniment.

Chalk Mixture. Contains chalk, sugar, gum, and cinnamon water.

Chameleon Mineral. Potassium permanganate or manganate. K_2MnO_4—changes from green to red ($KMnO_4$).

Chinosol. A soluble, crystalline, yellow powder of the quinolin group; disinfectant and deodorant.

Chloralum. A disinfectant composed of a solution of impure $AlCl_3$.

Chloric Ether. Alcoholic solution of $CHCl_3$.

Chloros. A disinfectant liquid containing 10 per cent. of available Cl.

Choke-damp. CO_2 in mines.

Chrome-green. A mixture of chrome-yellow and Prussian blue, or Cr_2O_3.

Chromeisen. A tough alloy of Fe and Cr.

Chrome-vermilion. Lead dichromate, $PbCr_2O_7$.

Chrome-yellow. Lead chromate, $PbCrO_4$.

Churchill's Tincture. Tinct. iodi composita; I, 2 dr.; KI, 4 dr.; glycerin, 1 dr.; alcohol, ad 1 oz.

Citrine Ointment. Mercuric nitrate ointment.

Clemens's Solution. Solution of arsenate and bromid of K.

Club Moss. Lycopodium.

Colcothar. Rouge, crocus, Fe_2O_3.

Cologne Spirit. Purified ethyl alcohol.

Colonial or Columbian Spirit. Methyl alcohol, CH_3HO.

Colophony. Rosin, common resin.

Common Salt. Sodium chlorid, NaCl.

Compound Jalap Powder. Jalap, 35; cream of tartar, 65.

Concentrated Lye. Impure mixture of NaHO and Na_2CO_3.

Condy's Solution. Sodium permanganate, 32 gr. in 1 pint of water.

Constant White. Barium tungstate.

Copperas. Green vitriol, ferrous sulphate crystals, $FeSO_4.7Aq$.

Copperas Blue. Cupric sulphate, $CuSO_4.5H_2O$.

Cordite. An explosive containing 58 per cent. nitroglycerin, 37 per cent. guncotton, and 5 per cent. "mineral jelly" (vaselin).

Corpse Light. Blue flame of burning methane in miners' safety lamp, seen before the mixture in air reaches an explosive ratio (1 to 5).

Corrosive Sublimate. Mercuric chlorid, bichlorid of mercury, $HgCl_2$.

Coster's Paste. Contains 2 drams I to ounce of tar.

Court Plaster. Emplastrum ichthyocollæ; isinglass (dried swimming-bladder of sturgeon) dissolved in water, alcohol and glycerin and spread on cloth.

Crab-orchard Salts. $MgSO_4$ plus $FeSO_4$, which obviates nauseous taste and prevents griping.

Crab's Eyes or Stones. Chalky concretions.

Cream of Tartar. Potassium bitartrate, $KHC_4H_4O_6$. Small crystals float on surface of liquid on rapidly cooling a hot solution.

Credé's Ointment. Colloidal silver, 15; water, 5; white wax, 10; benzoinated lard, 70.

Crocus of Antimony. Antimony vermilion or oxysulphid.

Crystals of Venus. Cupric acetate, $Cu(C_2H_3O_2)_2.H_2O$.

Cubic Niter. $NaNO_3$, which crystallizes in rhombohedra closely resembling cubes.

Dalmatian Powder. Powdered flowers of chrysanthemum cinerariæfolium.

Deshler's Salve. Compound resin cerate.

De Valangin's Arsenical Solution. Liquor. arsenici hydrochlor.; $AsCl_3$.

Dewees's Carminative. Mist. magnesiæ et asafœtidæ; contains magnesium carbonate and tinctures of asafœtidæ and opium and sugar and water.

Diachylon. Emplastrum plumbi.

Dialyzed Iron. Ferric hydrate held in solution by $FeCl_3$, the excess of which has been removed by dialysis.

Diana. Alchemic name of silver.

Dippel's Animal-oil. Pyridin, C_5H_5N.

Dobell's Solution. A mixture of 1½ dr. of carbolic acid, 4 dr. each of borax and baking soda, 14½ dr. of glycerin, and enough water to make 8 oz.

Donovan's Solution. An aqueous solution containing 1 per cent. each of AsI_3 and HgI_2.

Dover's Powder. Compound ipecac powder: 1 part each of ipecac and opium to 8 parts of sugar of milk.

Dutch Liquid. Ethene dichlorid, $C_2H_4Cl_2$.

Dutch White. Impure white lead, or a mixture of 3 parts $BaSO_4$ to 1 part of white lead.

Eagle or Excelsior Spirit. Deodorated wood alcohol.

Earth-wax. Ozokerite, hard paraffin, fossil wax.

Eau de Javelle. Solution of potassium hypochlorite, $KClO$.

Ehrlich's Syphilitic Remedy (606). Dioxydiamidoarsenobenzol.

Elastica. Caoutchouc.

Electrolytic Gas. H and O.

Elixir of Vitriol. Aromatic sulphuric acid.

Embalming Fluids. Arsenic, $ZnCl_2$, formalin, H_2O_2 or Na_2SO_3, and usually glycerin.

Emerald Green. Schweinfurth green, acetoarsenite of copper, $3CuAs_2O_4 + Cu(C_2H_3O_2)_2$.

Emery. Pulverized corundum.

Epsom Salts. Magnesium sulphate, $MgSO_4.7H_2O$.

Essence of Mirbane. Nitrobenzol.

Essence of Vinegar. Conc. acetic acid.

Ethiops Mineral. Black mercurous sulphid, Hg_2S.

Felwort. Gentian.

Ferrier's Snuff. Compound bismuth powder.

Fire-damp. Methane, marsh-gas, CH_4.

Fixed Air. Choke-damp, CO_2.

Fixed Niter. K_2CO_3.

Flake White. Pure carbonate of lead.

Flowers of Antimony. Antimonous oxid, Sb_2O_3.

Flowers of Arsenic. Arsenous oxid, As_2O_3.

Flowers of Benzoin. Benzoic acid, $HC_7H_5O_2$.

Flowers of Bismuth. Bismuth oxid, Bi_2O_3.

Flowers of Sulphur. Sublimed sulphur.

Flowers of Zinc. Zinc oxid, ZnO.

Fly Stone. Cobalt glance, a mixture of Co and As.

Foliated Earth of Tartar. Potassium acetate.

Fool's Gold. Iron pyrites, FeS_2.

Fowler's Solution. A 1-per-cent. aqueous solution of potassium arsenite, KH_2AsO_3, rendered alkaline with $KHCO_3$.

Freezine. Formaldehyd used as a preservative by milkmen.

French Chalk. Talc, soap-stone, steatite, magnesium silicate chiefly.

Friar's Balsam. Compound tinct. benzoin.

Fulminating Silver. $NHAg_2 = (NH_3 + Ag_2O - H_2O)$.

Fuming Liquor of Libarius. Solution of $SnCl_4$.

Fusel-oil. Amyl alcohol, $C_5H_{11}OH$.

Glass of Antimony. Fused antimony trisulphid, Sb_2S_3.

Glass of Borax. Borax-bead obtained by fusion.

Glauber's Salts. Sodium sulphate, $Na_2SO_4.10H_2O$.

Glonoin. Nitroglycerin; trinitrin.

Goddard's Drops. Aromatic spirit of ammonia.

Golden Seal. Hydrastis Canadensis.

Golden Sulphur. Antimony pentasulphid, Sb_2S_5.

Goulard's Extract and Cerate. Contain subacetate of lead, $Pb(C_2H_3O_2)_2$, $Pb(HO)_2$.

Graphine. Gas-carbon.

Gray Oil. Calomel suspended in lanolin and olive-oil.

Gray Powder. Hydrargyrum cum creta; Hg (38 per cent.) with chalk and honey.

Green Precipitate. Subacetate of copper, true verdigris.

Green Vitriol. Copperas, tutia, $FeSO_4.7H_2O$.

Gregory's Powder. Compound rhubarb powder.

Gregory's Salt. A double chlorid of morphin and codein.

Griffith's Antihectic Mixture. Mistura ferri comp.; $FeSO_4$, K_2CO_3 and aromatics.

Gros's Salt. $PtCl_2(NO_3)_2.4NH_3$.

Guignet's Green. Chromic hydrate obtained by heating a mixture of $K_2Cr_2O_7$ and boric acid, and extracting with water.

Gum Arabic. Acacia.

Hamburg White. Mixture of 1 part of white lead and 2 parts of $BaSO_4$.

Hard salt. Powdered alum.

Harle's Solution. Liquor sodii arsenitis.

Hartshorn. Ammonia, NH_3.

Heavy Carbureted Hydrogen. Ethene or olefiant gas, C_2H_4.

Heavy Earth. Baryta, BaO.

Heberden's Ink. Mistura ferri aromatica.

Hiera Picra. Aloes-and-canella powder, "hickery pickery."

Hive-syrup. Compound syrup of squill.

Hoffmann's Anodyne. Compound spirit of ether: 1 pint each of ether and alcohol, 6 fluidrams of ethereal oil.

Holy-wood. Guaiacum, lignum vitæ, pock-wood.

Homberg's Pyrophyrus. Made by igniting K, alum and charcoal.

Honey-dew. A viscid mixture of cane-sugar, dextrin, and invert-sugar, exuded from aphides on leaves.

Huxham's Tincture. Compound tincture of cinchona.

Ice-vinegar. Glacial acetic acid.

Iceland Moss. Cetraria.

Ignis Fatuus. Will-o'-the-wisp; spontaneous combustion of phosphine, H_3P, generated in marshy places.

India or Chinese Ink. Lampblack or burnt cork mixed with gelatin and water, flavored with camphor and musk; sepia.

Indian Salt. White sugar.

Insect Powder. Flower-heads of Persian pellitory.

Irish Moss. Chondrus.

Iron Pyrites. Native sulphid of iron, "fool's gold," FeS_2.

Italian Juice. Licorice.

Itch Ointment. Comp. sulphur ointment.

Ivory Black. Animal charcoal or bone-black.

James's Powder. Antimonial powder: 1/3 oxid of antimony, 2/3 calcium phosphate.

Japan Black. A varnish of asphalt, umber, turpentine, and linseed-oil.

Javelle Salt. NaClO.

Jesuit's Powder. Powdered cinchona-bark.

Jewelers' Gold. Alloys of gold and silver.

Kalk. Lime, CaO.

Kelp. Sea-weed ashes used as a source of I and Na_2CO_3.

Kermes Mineral. Oxysulphid of antimony.

King's Yellow. Orpiment, As_2S_3.

Kitchener's Pills. Simple rhubarb pills.

Konseals. Rice-flour capsules.

Kyan's Disinfectant. Solution of $HgCl_2$.

Labarraque's Solution. Solution of sodium hypochlorite, NaClO.

Lac Sulphuris. Pptd. S.

Lacmoid. An indicator composed of $NaNO_3$ and resorcin.

Lactin. Lactose.

Lady Webster Pill. Aloes pill.

Lana Philosophica. Zinc oxid, ZnO.

Lapis Divinus. One part each of alum, saltpeter, and $CuSO_4$ and 1/50 as much camphor as of the mixture.

Lapis Infernalis. Lunar caustic.

Lapis Lazuli. Natural ultramarine, a beautiful dark-blue pigment.

Laudanum. Tinct. opii (10 per cent. strength).

Laughing-gas. Nitrous oxid, N_2O.

Laveran's Solution. Quinin hydrochlorid, 3; antipyrin, 2; water, 6 parts. For injection (diluted) in malaria.

Lead-water. Diluted Goulard's extract, containing lead subacetate.

Ledoyen's Disinfectant. Contains lead nitrate.

Lemon-chrome. Chrome-yellow, $PbCrO_4$.

Light Carbureted Hydrogen. CH_4.

Lightning Powder. Lycopodium, "vegetable sulphur."

Lime. Calcium oxid, CaO.

Lime Liniment. A mixture of lime-water and cottonseed-oil.

Lime-water. Aqueous solution of $Ca(HO)_2$—about 0.15 per cent.

Liquid Smoke. Pyroligneous acid.

Lisle's Fever Powder. Pulv. antimonialis.

Litharge. Massicot, lead oxid, PbO.

Liver of Sulphur. Hepar sulphuris; sulphureted potassium, K_2S, K_2S_3, and $K_2S_2O_3$; a liver-brown solid made by heating S and K_2CO_3.

Lodestone. Native magnetic oxid of iron, Fe_3O_4.

Lokas, or Chinese Green. A pigment obtained by evaporating to dryness a mixture of lime and the juice of buckthorn-berries.

London Paste. Equal parts of quicklime and caustic soda, made into a paste with water; a depilatory.

London Purple. Arsenical residues from anilin-dye manufactories.

Lugol's solution. Iodin (5) held in solution by KI (10) in distilled water (85).

Luna. Alchemic name for silver.

Lunar Caustic. Stick silver nitrate, $AgNO_3$, toughened with 5-per-cent. KNO_3.

Macquer's Salt. Potassium arsenate.

Magendie's Solution. Morphin sulphate, 16 gr. to the ounce of water.

Magican. Galls.

Magistery of Bismuth. Subnitrate of bismuth.

Magnesia Alba. Magnesium carbonate.

Manhattan Spirit. Methyl alcohol.

Marguerite's Salt. $K_2CO_3.6H_2O$, $2Na_2CO_3.6H_2O$.

Marine Acid. HCl.

Marsden's Paste. One dram of pulv. acacia and 2 drams As_2O_3, mixed intimately and made into a paste with a little water.

Martius's Yellow. Dinitronaphtol; naphtol yellow, saffron yellow, golden yellow, Manchester yellow; used for mustard and macaroni.

Massicot. Amorphous PbO.

Matte. Impure metal (especially Cu) containing S. Called also "regulus, or white metal."

Methylene-blue. Tetramethylthionin chlorid.

Michel's Paste. Strong H_2SO_4 and powdered asbestos.

Microcosmic Salt. Sodium ammonium phosphate, $NaNH_4HPO_4$, so-called because of its presence in the residue of evaporated stale urine of man, the microcosm.

Milk of Asafetida. The white, aqueous emulsion of this gum.

Milk of Bismuth. Made from subnitrate dissolved in water with aid of HNO_3, then treated with NH_4OH.

Milk of Lime. Whitewash.

Milk of Magnesia. $Mg(HO)_2$ suspended in water, 1 part to 15.

Milk of Sulphur. Lac sulphuris, or precipitated sulphur, mixed with water.

Mineral Blue. Prussian blue, $Fe_4(FeCy_6)_3$.

Mineral Chameleon. K_2MnO_4. It absorbs CO_2 from the air and passes from green, through violet and blue, to purple $KMnO_4$.

Mineral Pitch. Asphalt.

Mineral White. Same as white lead.

Mineral Yellow. Lead oxychlorid.

Minium. Red lead, Pb_3O_4.

Monsel's Solution. Liquor ferri subsulphatis, $Fe_4O(SO_4)_5$.

Mosaic Gold. Brass or stannic sulphid, a golden-yellow powder used for bronzing.

Moth Balls. Tar balls; naphthalene.

Mountain-blue. Azurite, native basic cupric carbonate.

Mountain-green. Malachite, native basic cupric carbonate.

Muriatic Acid. Hydrochloric acid, HCl.

Music Metal. Alloy of Sn and Sb.

Mystery Gold. Alloy of 1 part Pt and 2 parts Cu with a little silver. It resists action of strong nitric acid.

Naples Yellow. A basic lead antimonate used in oil-painting.

Natron. Native sodium carbonate, Na_2CO_3.

Neutral Mixture. Solution of potassium citrate, $K_3C_6H_5O_7$.

Niter. Saltpeter, KNO_3.

Obsidian. Volcanic glass; trachyte or rhyolite.

Ocher. Native mixture of clay and ferric oxid, used as a paint.

Oil of Sulphur. H_2SO_4.

Oil of Vitriol. Sulphuric acid, H_2SO_4.

Oil of Wine. Ethyl sulphate, $(C_2H_5)_2SO_4$.

Olefiant Gas. Ethene, C_2H_4; so called because it makes an oily liquid with Cl.

Oleum Calcis. The thick, oily liquid resulting from deliquescence of $CaCl_2$ exposed to the air.

Opodeldoc. Camphorated soap liniment.

Oreide. A species of brass resembling gold.

Orpiment. As_2S_3.

Ox-gall. Fel bovis.

Oxidized Silver. Coating of thin layer of sulphid, obtained by heating together Ag and solution of K_2S.

Ozonized Ether. Solution of H_2O_2 in ether.

Ozonized Water. Aqueous solution of H_2O_2.

Packfong. German silver, or brass whitened by nickel.

Palsy Drops. Compound tincture of lavender.

Paradise-gas. Laughing-gas; N_2O.

Paregoric. Camphorated tincture of opium; contains 2 gr. opium per ounce.

Paris Black. Finely ground animal charcoal.

Paris Green. Impure Schweinfurth, or mitis, green, $Cu(C_2H_3O_2)_2$,-$3CuAs_2O_4$.

Paris Violet. Methyl-violet.

Paris Yellow. Lead chromate, $PbCrO_4$.

Patent Yellow. Lead oxychlorid, $PbCl_2$, 7PbO.

Pearl-ash. Crude potassium carbonate, K_2CO_3, calcined in a furnace till white.

Pearl Ointment. Zinc oxid ointment.

Pearl Powder or White. Subnitrate or subchlorid of Bi, or ZnO.

Pearson's Salt. Sodium arsenate, Na_3AsO_4.

Pectoral Powder. Pulvis glycyrrhizæ compositus.

Permanent White. Barium sulphate or carbonate—not darkened by H_2S.

Phlogiston. Hydrogen.

Phosgene-gas. Carbonyl chlorid, $COCl_2$.

Phosphonium. PH_4.

Pink Salt. Stannic chlorid with ammonium chlorid.

Pink Saucers. Carthamin, a red dye in safflower.

Plasma. Glycerite of starch.

Plaster of Paris. Calcined gypsum or calcium sulphate.

Plate Pewter. An alloy of Sb and Sn used for faucets and domestic utensils.

Platinum Black and Sponge. Finely divided Pt.

Plumbago. Black lead, graphite, a form of native carbon.

Plummer's Pill. Compound antimony pill, Sb_2S_3, Sb_2O_3, and calomel.

Poison-nut. Nux vomica.

Pompholix. Zinc oxid, ZnO.

Potash. Impure potassium carbonate, K_2CO_3.

Potassa. Potassium oxid or hydrate.

Potato-oil. Crude amyl alcohol.

Pot-metal. An alloy of Cu and Pb.

Pounce. Powdered gum juniper.

Powder Blue. Smalt, azure.

Precipitatum Per Se. HgO.

Preservaline or Rex Magnus. A mixture of borax and boric acid.

Preserving Salts. Impure Na_2SO_3, used by wholesale butchers to preserve meat.

Preston Salts. Same as official ammonium carbonate.

Prince's Powder. Red oxid of mercury, HgO.

Printers' Ink. Thoroughly boiled linseed-oil varnish, containing lampblack or other color and a little soap.

Proof-spirit. The old name applied to dilute alcohol 50.8 per cent., by weight; so called because this is the lowest alcoholic limit with which gunpowder will take fire.

Proprietary Drops. Comp. tincture of aloes or of myrrh.

Prussian Alkali. Potassium ferrocyanid.

Prussian Blue. Ferric ferrocyanid, $Fe_4(FeCy_6)_3$.

Prussian Brown. Cu_2FeCy_6.

Prussic Acid. Hydrocyanic acid, HCN.

Puce Oxid of Lead. Brown or peroxid of lead, PbO_2.

Pulvis Albus Romanis. Carbonate of magnesium.

Pulvis Purgans. Pulvis jalapæ comp.

Punk. Amidou, touchwood; made by steeping a fungus in saltpeter solution, and then drying thoroughly.

Purgative Mineral Water. Liq. magnesii citratis.

Purple of Cassius. Pigment made by mixing solutions of $AuCl_3$ and $SnCl_2$; probably $Au_2OSn_3O_5$; used in red pigments for glass and china.

Putty. Mixture of whiting and linseed-oil.

Putty Powder. Stannic oxid, SnO_2.

Pyroxilic Spirit. Wood alcohol.

Queen's Metal. An alloy of Sb, Sn, etc., used in jewelry.

Quevenne's Iron. Iron reduced by hydrogen.

Quicklime. Caustic lime, CaO.

Quicksilver. Metallic mercury.

Raddle or Riddle. Venetian red.

Radical Vinegar. Glacial acetic acid.

Ratsbane. Nux vomica, phosphorus, arsenic.

Red Blister. Unguentum hydrargyri iodidi rubri.

Red Borax. Ferric oxid.

Red Cerate. Calamine ointment.

Red Crocus. Ferric oxid.

Red Fire. $Sr(NO_3)_2$, 50 parts; $KClO_3$, 25 parts; powdered shellac or sugar, 25 parts; mixed without friction through a sieve.

Red Lead. Minium, plumbosoplumbic oxid $(PbO)_2PbO_2$.

Red Oil. Oleic acid as a by-product in the manufacture of stearic acid candles.

Red Precipitate. Red mercuric oxid, HgO.

Red Prussiate of Potash. Potassium ferricyanid, K_3FeCy_6.

Red Tartar. Argols, impure cream of tartar.

Regulus of Antimony. Metallic antimony.

Regulus of Arsenic. Metallic As obtained by reduction of As_2O_3 with powdered C.

Rex Metallorum. Gold.

Rhodanid. Sulphocyanate.

Ricord's Paste. A caustic made with conc. H_2SO_4 and powdered charcoal.

Rinman's Green. A pigment made by pptg. a mixture of zinc and cobalt sulphates with Na_2CO_3, and igniting ppt. after washing.

Rochdale Salt. Tartrate of sodium.

Roche and Roman Alums. Varieties of K alum.

Rochelle Salt. Potassium and sodium tartrate, $KNaC_4H_4O_6$.

Rock-oil. Petroleum.

Roll Turpentine. Resin, yellow wax and lard.

Roman Vitriol. $CuSO_4$.

Ros. Honey.

Rose Pink. Whiting colored with a decoction of Brazil wood and alum.

Rouge. Mineral: finely powdered ferric oxid. Animal: carmin and chalk. Vegetable: carthamin and chalk.

Rufus Pill. Pil. aloes cum myrrha.

Rust. Ferric oxid and hydrate.

Sacred Elixir. Comp. tinct. rhubarb.

Safety Oil. Petroleum naphtha.

Saffron: Of Mars: Fe filings and S; of steel: red oxid of Fe; of copper: suboxid.

Sal Absinthii. Potassium carbonate.

Sal Alemboth. Salt of wisdom; double chlorid of mercury and ammonium, NH_2HgCl.

Sal Ammoniac. Ammonium chlorid, NH_4Cl.

Sal Antihystericum. Acetate of potassium.

Sal Catharticum. Magnesium sulphate.

Sal Chalybis. Ferri sulphas.

Sal de Duobus. Potassium sulphate.

Sal Diureticus. Potassium acetate, $KC_2H_3O_2$.

Sal Enixum. Potassium bisulphate, $KHSO_4$.

Sal Febrifugum. Potassium acetate.

Sal Marinum or Fossile. Sodium chlorid.

Sal Mirabile. Sodium sulphate, Na_2SO_4.

Sal Perlatum. Sodium phosphate.

Sal Polychrest. Sal de duobus, potassium sulphate, K_2SO_4.

Sal Prunelle. Fused saltpeter, KNO_3, molded in small balls as a remedy for cattle.

Sal Soda. Impure Na_2CO_3, containing hydrate.

Sal Vegetabile. Potassium tartrate.

Sal Volatile. Ammonium carbonate or aromatic spirit of ammonia.

Saleratus. Potassium bicarbonate, $KHCO_3$.

Salt. Common salt; NaCl.

Salt of Lemon or Sorrel. Potassium binoxalate, KHC_2O_4.

Salt of Magnus. $PtCl_2$, $2NH_3$.

Salt of Mars or Steel. Sulphate of iron.

Salt of Phosphorus. Microcosmic salt.

Salt of Saturn. Lead acetate, $Pb(C_2H_3O_2)_2$.

Salt of Tartar. Pure potassium carbonate, K_2CO_3; so called because sometimes made by burning cream of tartar and lixiviating residue.

Saltpeter. Potassium nitrate, KNO_3.

Salts of Hartshorn. Ammonium carbonate.

Salts of Sorrel. $KHC_2O_4.H_2O$.

Saprol. A dark-brown, oily cresol much used in Germany as a disinfectant.

Saturn's Drops. Liquor plumbi subacetatis.

Saxon Blue. Geissen blue; mixture of Prussian blue and aluminum hydrate.

Scarlet Spirits. Solution of stannous nitrate.

Scheele's Acid. Dilute HCN.

Scheele's, or Swedish, Green. Cupric arsenite, $CuHAsO_3$.

Schleich's Solution for General Anesthesia. A mixture of 30 vol. chloroform, 80 ether and 15 benzin; b.p., 107.4° F.

Schleich's Solution (No. 2) for Infiltration Anesthesia. Cocain hydrochlorid, 1½ grains; morphin hydrochlorid, ⅛ grain; sodium chlorid, 3 grains; distilled water, 3⅝ fluidounces.

Schlippe's Salt. Sodium sulphantimonate, Na_3SbS_4, used in photography.

Schweinfurth, or Vienna, Green. Same as Paris green.

Scotch Magnesia. Magnesium carbonate.

Scotch Soda. Impure Na_2CO_3; barilla.

Sedative Salt. Boric acid, H_3BO_3.

Seidlitz Powder. Compound effervescing powder: Tartaric acid (35 gr.) in white paper; Rochelle salt (120 gr.) and sodium bicarbonate (40 gr.) in blue paper.

Seignette Salt. Same as Rochelle salt.

Shepherds' Stone. Bichlorid of mercury.

Shoe Blacking. Ivory black, molasses, and H_2SO_4.

Shoemakers' Black. Ferrous sulphate.

Siccoles. Castor-oil, santal oil, etc., in a dry form.

Sienna. Native oxid of iron used as a red pigment.

Silent Spirit. Dilute rectified alcohol, free from by-products of fermentation.

Silphine. Asafetida.

Smalt. Powdered glass colored blue with oxid of cobalt.

Smelling Salts. Sal volatile, chiefly ammonium carbonate.

Soda Ash. Crude Na_2CO_3.

Soda Saltpeter. Sodium nitrate, $NaNO_3$.

Soda-water. Water charged artificially with CO_2 under pressure.

Soldiers', or Troopers', Ointment. Unguentum hydrargyri mitis.

Soluble Cream of Tartar. Potassium borotartrate.

Soluble Prussian Blue. A compound intermediate between ferric ferrocyanid and ferrous ferricyanid.

Soluble Starch. Amylodextrin.

Soluble Tartar. Potassium tartrate.

Soluble, or Water, Glass. Sodium silicate, $Na_2Si_4O_9$.

Sore Throat Balls. Sal prunella balls.

Sory, or Shoemakers', Black. Sulphate of iron.

Speculum Metal. An alloy of Cu and Sn.

Speiss. Impure fused nickel arsenid.

Spelter. Commercial zinc or an alloy of equal parts Zn and Cu.

Spiegeleisen. Ferromanganese.

Spirit of Bones. An impure carbonate of ammonium.

Spirit of Chloric Ether. Spirit of chloroform.

Spirit of Hartshorn. Solution of NH_3 in alcohol. Ammonia was formerly made from horns and hides.

Spirit of Mindererus. Solution of ammonium acetate, made by neutralizing dilute acetic acid with ammonium carbonate.

Spirit of Niter. Nitric acid, HNO_3.

Spirit of Salt. Hydrochloric or marine acid, HCl.

Spirit of Tartar. Tartaric acid.

Spirit of Tin. $SnCl_4$.

Spirit of Vinegar. Dilute acetic acid, $HC_2H_3O_2$.

Spirit of Wine. Rectified ethyl alcohol, C_2H_5OH, of 84-per-cent. strength.

Spodium Steatite. ZnO.

Spunk. Touchwood, amadou.

Squibb's Mixture. One ounce each tinct. opium, tinct. capsicum and spt. camphor, 3 dr. chloroform, and alcohol up to 5 oz.

Steel Drops. Tincture of chlorid of iron.

Steel Fat. Calomel ointment used to prevent rust.

Steel Powder. Carbonate of iron.

Steel Wine. Wine of iron.

Steinbuhl Yellow. Barium chromate, $BaCrO_4$.

Stomachic Tincture. Tinct. cardamomi comp.

Stone Black. Carbo animalis.

Stone Mercury. Hydrarg. chloridi corros.

Strike. Liquor ammoniæ.

Stucco. Calcium sulphate, $CaSO_4$.

Sugar of Lead. Lead acetate, $Pb(C_2H_3O_2)_2$.

Sulphume. Trade name of anhydrous sulphurous acid, liquefied by cold and pressure, and supplied in hermetically sealed tins.

Sulphurated Antimony. Mixture of Sb_2S_3 and Sb_2O_3, used in vulcanizing rubber.

Sulphuric Ether. Ethylic ether, $(C_2H_5)_2O$.

Surfeit Water. Liquor ammon. acetatis.

Swedish Cholera Drops. Mistura opii et ipecac. comp.

Sweet Precipitate. Mercuric chlorid, $HgCl_2$.

Sweet Principle of Fats. Glycerin was formerly so called.

Sweet Spirit of Niter. Spiritus ætheris nitrosi, $C_2H_5NO_2$.

Talmi Gold. Alloy of Cu and Al.

Tar Balls. Coal-tar camphor, naphthalene.

Tar Spirit. Benzol, C_6H_6.

Tartar Emetic. Potassium antimonyl tartrate, $KSbOC_4H_4O_6$.

Tasteless Ague Drop. Liquor arsenicalis.

Tasteless Purging Salt. Sodium phosphate.

Tennant's Bleaching Powder. Calx chlorinata.

Terra Alba. Argilla, kaolin or bolus alba, a white argillaceous earth.

Thenard's Blue. A compound of the oxids of Al and Co.

Thenard's Green. Phosphate of cobalt.

Thermit. Mixture of granular Al and oxid of Fe, on top of which are placed some Mg filings mixed with BaO_2; lit with match; Al deoxidizes Fe, forming corundum.

Thieves' Vinegar. Aromatic acetic acid.

Tin Liquor. Solution of $SnCl_4$.

Tin Salt. Tin- ash or crystals: stannous chlorid, $SnCl_2.2H_2O$.

Tincal. Native borax, $Na_2B_4O_7.10H_2O$.

Tombac. Copper alloyed with As and used for imitation jewelry.

Toothache Crystal. Chloral hydrate.

Toothache Ice. Phenol and collodion.

Tooth Powders. Mostly prepared chalk.

Torrington's Drops. Comp. tinct. benzoin.

Tournesol. Litmus, laque blue.

Trip. Colcothar.

Tripoli. Diatomaceous earth, chiefly fine silica, used as a polishing powder.

Trona. Native sodium carbonate, Na_2CO_3.

Trona. Sodium bicarbonate.

Troopers' Ointment. Calomel ointment.

Tully's Powder. Compound morphin powder: 1 part of morphin to 20 each of camphor, licorice, and calcium carbonate.

Turnbull's Blue. Ferrous ferricyanid, $Fe_3(FeCy_6)_2$.

Turner's Cerate. Calamine ointment.

Turner's Yellow. Lead oxychlorid.

Turpeth Mineral. Queen's yellow, subsulphate of mercury, $HgSO_4.2HgO$.

Turnsol. Litmus.

Tutenag. Zinc.

Tutty. Impure zinc oxid, ZnO.

Ultramarine, or Washing, Blue. Lapis lazuli, a blue pigment composed of sodium sulphid and aluminum sodium silicate.

Umber. Sienna or chestnut brown, native aluminum silicate with oxids of iron and manganese, used as brown paint; darkened in tint by burning.

Unction. Calomel ointment.

Uranium Yellow. Sodium uranate, NaO, $2UO_3$.

Usquebaugh. Distilled and sweetened tinctures of mace, saffron, orange, and citron peels.

Valangin's Solution. Solution of As_2O_3 with dilute HCl.

Vallet's Mass. Ferrous carbonate in pill mass.

Van Swieten's Liquor. Liquor hydrarg. bichlor.

Varec. Kelp, or ash of seaweeds.

Vegetable Alkali. Caustic potash.

Vegetable Black. Finely ground wood charcoal.

Vegetable Sulphur. Lycopodium; club moss.

Venetian Red. An ocher, the color of which is due to ferric oxid.

Venetian Sublimate. Corrosive sublimate.

Venus. Alchemic name for copper.

Verdigris. A mixture of basic copper acetates.

Verditer Green. Basic copper carbonate.

Vermilion. Artificial mercuric sulphid, HgS.

Victoria Yellow. Dinitrocresol; anilin orange, Victoria orange; saffron substitute used for coloring cakes and liquors.

Vienna Green. Same as Schweinfurt green; acetoarsenite of copper.

Vienna Paste. Potassa cum calce.

Vinegar. Acetum, or dilute acetic acid.

Vinegar Essence. Conc. acetic acid.

Vinegar of Lead. Liquor plumbi subacetatis, a solution of PbO in $Pb(C_2H_3O_2)_2$ solution.

Violet Powder. Pure starch scented with orris root.

Virgin Oil. Olive-oil.

Virgin's Milk. Solution of benzoin.

Vitrifiable Earth. Silica.

Vitriolic Acid. H_2SO_4.

Volatile Alkali. Ammonia.

Volatile Liver of Sulphur. Ammonium sulphid.

Volatile Salt of Urine or of Vipers. Ammonium carbonate.

Vomiting Salt. $ZnSO_4$.

Wade's Drops. Tinct. benzoin comp.

Waken Beggar. Pulv. hellebor. alb.

Warburg's Tincture. Tinct. antiperiodica; contains 2 per cent. quinin.

Warming Plaster. Emplastrum picis cantharidatum.

Washing Blue. Artificial ultramarine, or starch and indigo.

Washing Soda. Sodium carbonate; Na_2CO_3.

Whisky. Spiritus frumenti.

White Acid. A mixture of HF and NH_4F used for etching glass.

White Arsenic. Arsenous oxid, As_2O_3.

White Iron Pyrites. Marcasite, FeS_2.

White Lead. Basic lead carbonate, $(PbCO_3)_2Pb(HO)_2$.

White Metals. Alloys of Ni with Cu and Zn: albata, British plate, electrum, pakfang, tutenag, white copper, etc.

White Precipitate. Ammoniated mercury, NH_2HgCl.

White Tartar. Cream of tartar.

White Vitriol. Zinc sulphate, $ZnSO_4$.

White Zinc. $ZnCO_3(ZnO)_2.3H_2O$.

Whitewash. Liq. plumbi subac. dil.

Whiting. Prepared chalk, $CaCO_3$, or white clay.

Wine Stone. Argol.

Wonderful Salt. Sodium phosphate.

Wood-oil. Gurgun balsam.

Wood-spirit, or Naphtha. Methyl alcohol, CH_3OH.

Wood-vinegar. Pyroligneous, or impure acetic, acid.

Wool-fat. Lanolin.

Yeast. Cerevisia; fermentum.

Yelk of Egg. Vitellus.

Yellow Ointment. Unguentum hydrargyri nitratis.

Yellow Metal. Brass.

Yellow Pigment. Lead chromate, $PbCrO_4$.

Yellow Prussiate of Potash. Potassium ferrocyanid, K_4FeCy_6.

Yellow Ultramarine. Barium chromate, $BaCrO_4$.

Yellow Wash. Mercuric oxid, HgO, made by adding $HgCl_2$ to lime-water.

Zaffre. Impure cobaltous oxid from roasting sand and ore.

Zinc Blende. Native ZnS.

Zinc, or Chinese, White. Zinc oxid, used as paint.

COMPOSITION OF CERTAIN PROPRIETARY REMEDIES.

Anesthetics, Local.—Acoin, diparaanisyl-monophenetyl-guanidin hydrochlorid, $(CH_3O.C_6H_4NH)_2:C:NC_6H_4.OC.H_5$; alypin, hydrochlorid of benzoyl-tetramethyl-diamino-ethyl isopropyl alcohol, $(CH_3)_2N.CH_2.C.C_2H_5.C_6H_5COO.CH_2.N(CH_3)_2HCl$; anesthesin, paraamidoethyl benzoate, $C_6H_4NH_2COOC_2H_5$; chloretone, acetone chloroform, $C.CCl_3.CH_3.OH.CH_3$; coryfin, menthol ethyl glycolic ester, $C_{10}H_{19}O.COCH_2.OC_2H_5$; dentalon, saturated solution of chloretone with oils of clove, wintergreen and cinnamon; eucain β, $C_{15}H_{21}NO_2$; holocain, paradiethoxyethenyldiphenylamidin, $CH_3C:(N.C_6H_4OC_2H_5)NH.C_6H_4OC_2H_5$; kelene, ethyl chlorid, C_2H_5Cl; nervocidin, an alkaloid from the Indian Gasu-Basu; neurocaine, billets containing 5 mg. cocain hydrochlorid; nirvanin, diethylglycocoll-p-amido-oxybenzoyl-methyl ester hydrochlorid, $HCl(C_2H_5)_2N.CH_2.CO.NH.C_6H_3(OH).COOCH_3$; novocain, hydrochlorid of paraaminobenzoyl-diethyl-aminoethanol, $C_6H_4NH_2.COO.C_2H_4.N(C_2H_5)_2$; obtundo, contains chloretone, cocain, nitroglycerin, thymol, menthol and oils of cloves, wintergreen and eucalyptus; stovain, diethylamino benzoyldimethyl-ethyl-carbinol hydrochlorid, $C_6H_5CO(CH_3)CO(C_2H_5)CH_2.N(CH_3)_2.HCl$.

Anesthetics, General.—Anesthol (Meyer), a mixture of chloroform, ether and ethyl chlorid; somnoform (narcoform), ethyl chlorid 60, methyl chlorid 35, and ethyl bromid 5 parts.

Alkalizers ("Uric Acid Remedies").—Alkalithia, caffein 1, Li_2CO_3 5, sodium and potassium bicarbonate 10 each, mixed with 35 parts of an effervescent salt; Eno's fruit salt, $NaHCO_3$, tartaric and citric acids; piperazin, diethylendiamin, $HN(CH_2)_2:(CH_2)_2NH$; sidonal, piperazin quinate, $NH(CH_2.CH_2)_2NH.C_6H_7(OH)_4COOH$; thialion, mixture of sodium sulphate and citrate with small amounts of Li.

Antiseptics and Disinfectants.—Asaprol (abrastol), calcium betanaphtol-monosulphonate, $Ca(C_{10}H_6(OH)SO_3)_2.3H_2O$; aseptol, a 33-per-cent. solution of sozolic (orthophenolsulphonic) acid; cerevisine, pure desiccated yeast; cresylone, contains 50 per cent. cresol; euthymol, contains oils of eucalyptus and wintergreen, fluidextract wild indigo. boric acid, menthol and thymol; formalin, 40-per-cent. solution of formaldehyd; germicidal soap, contains 1 or 2 per cent. HgI_2 with hard or soft soap; lysol, alkali compounds with heavy oil of tar (cresols); microcidin, fused mixture of naphtol and caustic soda; pasteurine, formaldehyd and glycerin; phenol sodique, contains 47 gr. phenol and 8 gr. NaHO to an ounce of water; sanitas, oxidation product of turpentine; septoform, formaldehyd and higher phenols in an alcoholic soft soap; solveol, cresols dissolved in sodium cresotate; sublamin, mercuric sulphate ethylene diamin, $HgSO_4(CH_2NH_2)_2.2H_2O$; tachiol, silver fluorid, AgF; vapocresolene, crude carbolic acid.

Alteratives.—Arrhenal (arsynal), sodium methyl arsenite, $OAsCH_3O_2Na_2.5H_2O$; arsycodile, sodium cacodylate; atoxyl, meta-arsenic-anilid, $C_6H_5NHAsO_2$; calcidin, calcium iodid, iodin, CaO and starch; cancroin (cancer serum), phenolneurin citrates; cypridol, HgI_2, 1 per cent. in oil; ecthol, contains echinacea angustifolia and thuja occidentalis; echitone, contains echinacea, viola and iris; eigons, compounds of I and Br with albumin; enesol, salicylarsenite of mercury; eusoma, echinacea compound; iodalbin, iodin albumin compound; iodia, extracts of green roots of stillingia, helonias, saxifrage and menispermum; iodipin, iodized sesame oil containing 10 per cent. I; mercauro, bromids of Au, As and Hg; sajodin, monoiodobehenate of calcium; Truneck's serum, contains Na_2SO_4, NaCl, Na_2HPO_4, Na_2CO_3, K_2SO_4 and water.

Analgesics, Anodynes and Antipyretics.—Ammonol, phenalgin, contains acetanilid, $NaHCO_3$, ammonium carbonate and anilin yellow; analgesin, a citrated antipyrin-caffein mixture; antikamnia, contains phenacetin, caffein, citric acid and $NaHCO_3$; exalgin, methyl acetanilid,

$C_6H_5N.CH_3.COCH_3$; hemicranin, phenacetin, caffein and citric acid; kryofine, methoxyacet-p-phenetidin, $CH_3.OCH_2CO.NH.C_6H_4OC_2H_5.H_2O$; lactophenin, lactylphenetidin, $C_6H_4(OC_2H_5)(NH.CH_3.CHOH.CO)$; methacetin, paraoxymethylacetanilid, $C_6H_4(OCH_3)NH.COCH_3$; migrainin, antipyrin-caffein citrate; narcyl, chlorhydrate of ethyl narcein; papine, an opiate; phenacetin, acetphenetidin, $C_6H_4(OC_2H_5).NH.CH_3.CO$; pyramidon, dimethyl-amido-antipyrin, $C_{13}H_{17}N_3O$; salfene, acetanilid and $NaHCO_3$; svapnia, purified opium; thermol, acetyl-salicyl-phenetidin, $C_6H_4NH.C_6H_4O.COCH_3.CO.OC_2H_5.3H_2O$.

Antiblennorrhagics.—Arhovin, ester of thymol benzoic acid; belnal, carbonic acid ester of santalol; gonosan, kawasantal; methyl santal; santyl, salicylate of santal, $C_6H_4OH.COOC_{15}H_{23}$.

Antirheumatics and Antineuralgics.—Aspirin, acetyl salicylic acid, $C_6H_4.O(CH_3CO)COOH$; betulol, contains methyl salicylate; calcalith, contains colchicin and salts of Ca and Li; citarin (aresin), neutral sodium salt of dibasic anhydromethylene citric acid, $(CH_2.COONa).CO.(CH_2.O.CO).CH_2.COONa$; colchisal, colchicin and methyl salicylate; liqueur de Laville, quinin and colchicin; lysidin, ethylene-ethenyl-diamin hydrochlorid; melachol, Na_2HPO_4, $NaNO_3$, citric acid and water; novaspirin, methylene citric acid ester of salicylic acid, $CH_2(CO_2.C_6H_4CO_2H).C(O.CH_2.COO).CH_2(CO_2.C_6H_4CO_2H)$; rheumagon, like melachol; salacetin, phenylamin acetosalicylate; saligenin (diathesin), ortho-oxybenzyl alcohol, $C_6H_4HO.CH_2.OH$; salit, salicylic acid ester of borneol, $C_{10}H_{17}O.CO.C_6H_4OH$; salipyrin, antipyrin salicylate; salocoll, phenocoll salicylate, $C_6H_4(OC_2H_5)NH.COCH_2.NH_2.C_7H_6O_3$; salophen, acetyl-p-amido-salol, $C_6H_4(OH)COO.C_6H_4.NHCOCH_3$; saloquinine, $C_6H_4OH.COO.C_{20}H_{23}N_2O$; sidonal, piperazin quinate, $C_{18}H_{34}N_2O_{12}$; spiroform, acetyl-phenyl-o-oxybenzoic acid, $C_6H_4(O.CH_3CO)COOC_6H_5$; spirosal, salicylic monoglycol ester, $C_6H_4(OH)COO.CH_2CH_2OH$; tongaline, contains cimicifuga, colchicin, pilocarpin and salicylic acid.

Artificial Foods and Substitutes.—Aleuronat, wheat gluten; antidiabetin, saccharin and mannite; bovinine, dried beef blood; diabetin, levulose or fructose; dulcin (sucrol), paraphenetol carbamid, $CO(NH_2)NH.C_6H_4OC_2H_5$; ferrosomatose, somatose containing 2 per cent. Fe; garantose and glusid, saccharin; kefir, matzoon, koumiss, fermented milk; lactosomatose, albumins of milk with 5 per cent. tannin; malted milk, made from flour baked, mixed with milk or cream and then dried and malt added; meatox, conc. beef powder; Mellin's food, made by mixing equal parts of wheat flour and barley malt with bran and $KHCO_3$; nutrose, acid Na salt of casein; panopepton, made from whole wheat and lean beef; peptonoids, predigested beef, milk and wheat; plasmon, freshly pptd. casein; protogen, made by heating egg-albumin with formaldehyd; roborat, a dextrinized albuminoid prepared from wheat, corn and rice; sanose, casein and albumose; somatose, albumoses and peptons; sycose, saccharin; tropon, degelatinized flesh treated with H_2O_2.

Cardiants.—Digalen, soluble digitoxin; digitalon, active principles of digitalis; erythrol tetranitrate, $C_4H_6.(ONO_2)_4$; hydragogin, contains digitalis, squill, strophanthus and oxysaponin; oxaphor (oxycamphor), $C_{10}H_{16}O_2$.

Catarrhal Remedies.—Forman, chlormethyl-menthyl ether; glycothymoline, contains borax, benzoic and salicylic acids, menthol, thymol, Betula lenta, Pinus pumilio, glycerin and alcohol; menthoform, chlormethyl-menthyl ether with an equal amount of vaselin; menthoxol, 3 per cent. H_2O_2 containing 1 per cent. menthol and 3 per cent. alcohol; rhinalum wafers, contain alum, $HgCl_2$, hydrastin, formaldehyd, lanolin, menthol and cacao butter.

Cholagogs.—Chologestin, contains sodium glycocholate and salicylate, pancreatin, $NaHCO_3$ and alcohol; eunatrol, acid sodium oleate; pancrobilin, gall and pancreatin extract; probilin, contains salicylic acid, sodium oleate and stearate, menthol and phenolphthalein; veracolate, cholic acid with cascara sagrada.

Clay Poultices. — These owe their hygroscopic properties to the contained glycerin. They have a number of names, such as antiphlogistine, kaolinite, kaotol and marach.

Cod-liver (and other) Oil Preparations. — Hydroleine; egmol, lofotol, morrhuol, morrhuvin, ozomoru, Russell's emulsion, sevetol, Scott's emulsion, etc.

Cough Remedies.—Dionin, ethylmorphin hydrochlorid, $C_{17}H_{17}NO(OH)(OC_2H_5)HCl.H_2O$; heroin, diacetyl morphin, $C_{17}H_{17}NO(O.CH_3.CO)_2$; herotone, contains heroin, guaiaconic acid, benzoic acid and terpin hydrate; kügloids, contain quinin glycerophosphate and benzoated creosote and eucalyptol; peronin, morphin-benzyl ester hydrochlorid, $C_{17}H_{18}NO_2.O.CH_2C_6H_5.HCl$; pertussin, compound syrup of thyme; rami syrup, syrup of bromoform; tussol, phenyl-glycol-antipyrin.

Counter-irritants. — Capsolin, capsicum, camphor, and oils of cajuput, turpentine and croton; mesotan, methoxymethyl ester of salicylic acid, $C_6H_4(OH)COOCH_2OCH_3$; monotal, methyl-glycolic acid ester of guaiacol, $C_6H_4(CH_3)O.OC.CH_2O.CH_3$; veratrol, dimethyl-pyrocatechin, $C_6H_4(OCH_3)_2$.

Dentifrices. — Dental, menthol and thymol; dentaline, thymol, borax, baking soda, ext. catechu and oil of peppermint; listerine, contains constituents of thyme, eucalyptus, baptisia, gaultheria, mentha arvensis, and benzoboracic acid; odol, contains salol, saccharin and peppermint in alcohol.

Digestants. — Caroid, papain; cellulin, a ferment derived from fungi; diazyme essence, amylolytic enzyme of pancreas; enzymol, sterile gastric juice; felsin, contains fel bovis, pepsin, pancreatin and capsicum; fermenlactyl, pure lactic ferment; holadin, extract of entire pancreas gland; ichthalbin, ichthyol albumin; lactopeptine, contains milk sugar, pepsin, pancreatin, diastase, HCl and lactic acid; lactone, lactic acid bacilli; maltzyme, conc. extract of malt; orexin, phenyl-dihydro-quinazolin tannate, $C_{14}H_{12}N_2.C_{14}H_{10}O_9$; pankreon, a pancreas extract (with tannin) which resists gastric digestion; papain, papayotin, papoid, digestive ferment of papaw (plant pepsin); pegmin, mixture of rennin and lactose; peptenzyme, nucleoenzymes of all alimentary glands; phaselin, active constituent of bean of Dilkos Mexicano; seng, an extract of Panax schinseng; takadiastase, a ferment obtained through action of spores of fungus aspergillus orizæ on steamed rice.

Diuretics. — Agurin, sodium-theobromin acetate, $C_7H_7N_4O_2Na + CH_3COONa$; anasarcin, contains active principles of Oxydendron arboreum, Sambucus Canadensis and Urginea scilla; diuretin, sodium-theobromin sodium salicylate; hydragogin, contains tincts. digitalis and strophanthus, scillipicrin, scillitoxin and oxysaponin; lycetol, dimethyl-piperazin tartrate, $NH.(CH_2CHCH_3)_2{:}NH.C_2H_2.(OH)_2.(COOH)_2$; piperazin, diethylene-diamin (ethylenimin, dispermin); sanmetto, true santal and saw palmetto in an aromatic vehicle; theocin (synthetic theophyllin), dimethylxanthin; tritipalm, saw palmetto and triticum repens; xanol, sodium-caffein salicylate.

Dusting Powders. — Airol (airoform), bismuth oxyiodogallate; alumnol, aluminum-beta-naphtol disulphonate, $Al_2(C_{10}H_5(OH)(SO_3)_2)_3$; aristol, dithymol diiodid; boral, aluminum borotartrate; calomelol, colloidal or soluble calomel; dermatol, bismuth subgallate; dermogen, contains 55 per cent. ZnO_2; dermol, bismuth chrysophanate, $Bi(C_{15}O_9O_4)_2Bi_2O_3$; dolomol, magnesium stearate; emulgates, prepared from equal parts of oils and lecithalbumins; europhen, isobutyl-orthocresol iodid, $C_6H_3(C_4H_9)(CH_3)(OI).C_6H_2(CH_3)(:O)C_4H_9$; glutol (glutoform), formaldehyd-gelatin; iodoformin (iodoformolin), hexamethylenetetramin-iodoform, $CHI_3(CH_2)_6N_4$; iodol, tetraiodopyrrol, C_4I_4NH;

iodomuth, bismuth oxyiodo-methylene digallate; nosophen, tetraiodophenolphthalein, $C_6H_4.CO.C.O.(C_6H_2I_2OH.)_2$; orphol, basic beta-naphtol-bismuth, $(C_{10}H_7O)_3Bi.3H_2O$; orthoform, p-amido-m-oxybenzoic-methyl ester, $C_6H_3.(COO.CH_3)(NH_2)(OH)1:4:3$; sanoform (iodozon), diiodosalicylic-methyl ester, $C_6H_2I_2(OH)COOCH_3$; sozoiodols, salts of paraiodophenol sulphonic acid, $C_6H_3.OH.SO_3H$; thioform, basic dithiosalicylate of bismuth, $2(S.C_6H_3(OH)COOBiO) + Bi_2O_3.2H_2O$; Tyree's antiseptic powder contains borax, alum, glycerin, phenol, thymol, menthol and wintergreen; vioform (nioform), iodchlor-oxyquinolin, $C_9H_3N.OH.I.Cl$; xeroform, tribrom-phenol-bismuth, $(C_6H_2Br_3OH)_2.Bi_2O_3$.

Emmenagogs.—Ergoapiol, contains apiol, ergotin, aloin and oil of savin; ergone, purified extract of ergot, preserved with chloretone; ergotole, each minim represents 2½ gr. ergot.

Hematinics.—Carniferrin, iron salt of phospho-acids of meat; fermang, peptonate of Fe and Mn; ferratin, ferric albuminate; ferratogen, iron-nuclein; ferrosomatose, meat albumoses with 2 per cent. Fe; hemaboloids, alkaline 1-per-cent. solution of iron peptonate; hematogen, hemoglobin in aromatic excipient; hemol, reduced hemoglobin; hemoquinine, combination of Fe, Mn, As and quinin; marsyle, iron cacodylate; neoferrum, maltopeptonate of Fe and Mn with a little As in maltine and sherry wine; peptomangan, Fe and Mn in combination with pepton; triferrin, ferric paranucleinate.

Hypnotics and Sedatives.—Acetal, ethylidene-diethyl ether, $CH_3CH(C_2H_5O)_2$; bromidia, contains chloral hydrate, NaBr, ext. hyoscyamus and ext. cannabis Indica; chloretone, acetone chloroform; hedonal, methyl-propyl-carbinol-urethane, $CO(NH_2)OCH.(CH_3)C_3H_7$; hypnal, monochloral antipyrin, $C_{11}H_{12}N_2O.CCl_3CH(OH)_2$; neurilla, active principles of scutellaria; neuronal, diethyl-brom-acetamid, $(C_2H_5)_2(Br).CONH_2$; neuronidia, veronal elixir; somnos, glycerin and chloral hydrate, $C_9H_{11}O_6Cl_9$; sulphonal, diethyl-sulphon-dimethyl-methane, $(CH_3)_2.C.(SO_2C_2H_5)_2$; tetronal, diethyl-sulphon-diethyl-methane, $(C_2H_5)_2.C.(C_2H_5SO_2)_2$; trional, diethyl-sulphon-methyl-ethyl-methane, $CH_3.C_2H_5.C.(C_2H_5SO_2)_2$; urethane, carbamic ethyl ester, $CO(NH_2)_2.OC_2H_5$; validol, menthol and valeric acid; veronal, diethyl-malonyl-urea, $CO(NH.CO)_2:C:(C_2H_5)_2$.

Internal Secretions and Serums.—Adnephrin, adrenal, adrenalin and adrin are names given to the 1:1000 solution of adrenal active principle; antithyroidin, serum from blood of sheep deprived of thyroid gland; basedowsan, similar to antithyroidin; epinephrin and epirenan, similar to adrenalin; nephritin, prepared from kidney cells; oöphorin and ovarin, prepared from ovaries of cows; paranephrin, an adrenal product; pollantin, a hay fever serum prepared by introducing pollen of the graminaceæ into the blood of animals; protonuclein, prepared from gland cells; rodagen, serum prepared from milk of goats from which the thyroid gland has been removed; scarlatin, a scarlet fever serum prepared from immunized animals; suprarenin, same as adrenalin; thyreoidectin, derived from blood of animals from which thyroid gland has been removed; thyreoidin, thyroid extract; trypsogen, said to contain enzyme of islands of Langerhans with tryptic and amylolytic pancreatic ferments.

Intestinal Antiseptics.—Acetozone (benzozone), benzoyl-acetyl peroxid, $C_6H_6CO.O.O.CH_3CO$; alphol, alpha-naphtol salicylate, $C_{10}H_7O.CO.C_6H_4.OH$; alphozone, succinic dioxid, $(COOH.CH_2CH_2CO)_2O_2$; benzonaphtol, naphtol benzoate, $C_6H_5COOC_{10}H_7$; benzosol, guaiacol benzoate, $C_6H_4OCH_3.COO.C_6H_5$; betol, salinaphtol, $C_6H_4OH.COOC_{10}H_7$; bismal, bismuth-methylene digallate, $4C_{15}H_{12}O_{10} + 3Bi(OH)_3$; bismutan, contains bismuth, resorcin and tannin; bisol, soluble bismuth phosphate; calolactose, bismuth subnitrate, calomel and lactose; creosal (tanosal), creosote tannate; creosotal, creosote carbonate; eudoxin, bismuth nosophenate; geosot, guaiacol valerate, $C_6H_4(OCH_3)O.CO.C_4H_9$;

glycozone, glycerin saturated with ozone; guaialin, guaiacol, benzoin and formaldehyd; guaiamar (oreson, oresal), guaiacol-glyceryl ether, $C_6H_4(OCH_3)OCH_2.CHOH.CH_2OH$; salacetol (salantol), salicylic acetol, $C_6H_4(OH)COO.CH_2COCH_3$; styracol, guaiacol cinnamate, $C_6H_4.OCH_3.O.OC.CH:CH_2OH$; tricresol (enterol), a mixture of ortho-, meta- and para- cresols.

Laxatives.—Kasagra, palatable fluidextract of cascara; lapactic pills, aloin, strychnin, belladonna and ipecac; laxatol, phenolphthalein; laxol, castor-oil sweetened with saccharin; prunoids, phenolphthalein, cascara, ipecac and prunes; purgatin (purgatol), diacetyl ester of anthrapurpurin, $C_{14}H_6OH(CH_3CO.O)_2O_2$; purgen, phenolphthalein; sal hepatica, Rochelle salt with Li and Na phosphate; salithia, $MgSO_4$, sodium tartrate and a Li salt.

Mydriatics.—Eumydrin, atropin methyl nitrate; euphthalmin, hydrochlorid of phenyl-glycolyl-n-methyl-beta-binyl-diacetone alkamin, $C_{17}H_{25}NO_3.HCl$.

Nervines.—Bornyval, bornyl valerate, $C_{10}H_{17}.O.C_5H_9O$; bromalin, hexamethylentetramin-bromethylate, $(CH_2)_6N_4C_2H_5Br$; bromocoll, bromtannin pptd. with gelatin; celerina, contains celery, kola, viburnum and coca; hysterol, bornyl valerate; nervine, sodium glycerophosphate; neurilla, fluidextract of scutellaria with aromatics; sanatogen, casein and sodium glycerophosphate; tonols, preparations of glycerophosphates; validol, menthol valerate, $C_{10}H_{19}.O.CO.C_4H_9$; valyl, valeric acid diethylamid, $C_4H_9.CO.N(C_2H_5)_2$.

Nucleinates. — Cuprol, copper; ferrinol, iron; histogenal, nucleinic acid and sodium methylarsenate; mercurol, mercury; nargol, silver.

Ointments and Lubricants.—Lubraseptic, Irish moss, formaldehyd, boric acid, etc.; resorbin, ointment vehicle made by emulsifying almond-oil and water by means of yellow wax and gelatin, to which some lanolin is added; unguentine, contains alum, phenol, ichthyol and a petrolatum base; unguentum Crede, 10 per cent. ointment of collargolum; vasogen, partially oxidized mineral-oil base for ointments; albolene, benzoinol, cosmolene, glymol, lavolin, petrolene and terraline.

Oxidizers.—Biogen (hopogan), magnesium peroxid, MgO_2; calcium peroxid, CaO_2; calox, evolves 2 per cent. H_2O_2; ectogen, zinc peroxid, ZnO_2; gorit, CaO_2; hydrozone, H_2O_2 solution of 9 per cent. strength: oxone (oxylith), cubes of sodium peroxid; perglutyl, H_2O_2 solidified with gelatin and glycerin; perhydrol, 30 per cent. H_2O_2; peroxoles (menthoxol, camphoroxol, thymoxol, naphthoxol), alcoholic solutions of camphor, menthol, naphtol and thymol containing 3 per cent. H_2O_2; pyrozone, 3 per cent. (10-volume) H_2O_2 solution.

Parasiticides.—Epicarin, betaoxynaphthyl-orthooxymetatoluic acid, $C_6H_3.OH.COOH.CH_2(C_{10}H_6OH)$; eudermol, nicotin salicylate, $C_{10}H_{14}N_2.C_7H_6O_3$.

Quinin Substitutes. — Aristochin, diquinin carbonate, $(C_{20}H_{23}N_2O)_2CO_3$; basicin (corticin), one-third caffein and two-thirds quinin hydrochlorid; euchinin, quinin carbonic ethyl ester, $C_2H_5.O.CO.O.C_{20}H_{23}N_2O$.

Resolvents.—Fibrolysin, thiosinamin with ½ mol. sodium salicylate; iothion, biiodohydroxypropane; thiol, prepared by sulphurating paraffin-oil by heating with 10 per cent. S; thiosinamin (rhodallin), allyl-thiourea, $CS.NH_2.NH.C_3H_5$.

Silver Products.—Albargin, silver gelatose; argentamin, ethylendiamin silver phosphate; argentol, silver oxychinoseptolate, $C_9H_5N(OH)SO_3Ag$; argentose, silver and nucleoproteid; argonin, silver-casein; argyrol, silver vitellin; collargol, colloidal silver; novargan, silver albumin; protargol, protein silver (8.3 per cent.).

Skin Remedies.—Endermol, mixture of stearic amid with paraffin hydrocarbons; lanogen, mixture of vaselin and wool-fat; lenigallol,

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